OHIO RIVER BASIN

TRIBUTARY NORTH BRANCH PIGEON CREEK, WASHINGTON COUNTY

PENNSYLVANIA

BENTLEYVILLE DAM

NDI ID NO. PA-1096

DER ID NO. 63-49

BENTLEYVILLE WATER AUTHORITY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

Prepared By

L. ROBERT KIMBALL & ASSOCIATES

CONSULTING ENGINEERS & ARCHITECTS

EBENSBURG, PENNSYLVANIA

15931

FOR

DEPARTMENT OF THE ARMY

BALTIMORE DISTRICT CORPS OF ENGINEERS

BALTIMORE, MARYLAND

21203

JUNE, 1981

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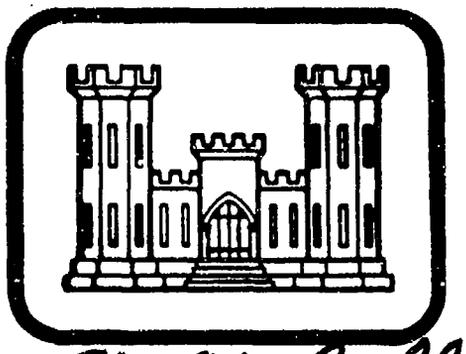

DACW31-81-C-0012

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in detemining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I REPORT
NATIONAL DAM INSPECTION REPORT

NAME OF DAM	Bentleyville Dam
STATE LOCATED	Pennsylvania
COUNTY LOCATED	Washington
STREAM	Tributary to the North Branch of Pigeon Creek
DATES OF INSPECTION	November 5, 1980 and May 12, 1981
COORDINATES	Lat: 40° 8.9' Long: 80° 1.5'

ASSESSMENT

The assessment of Bentleyville Dam is based upon visual observations made at the time of inspection, review of available records and data, hydraulic and hydrologic computations and past operational performance.

The Bentleyville Dam appears to be in poor condition. No maintenance program exists for the dam and the lack of maintenance has led to a general deterioration of the structure. An upstream shut-off exists for the 12" drainline, but the capability of the valve to operate is questionable. Wet areas were observed on the downstream slope of the dam. One area observed at the right abutment contact; and a second wet area was observed on the downstream slope adjacent to the right spillway wingwall, approximately 10 feet below the crest. The seepage should be investigated to ascertain its effects on the stability of the structure. The spillway is in a deteriorating condition and the concrete in the channel walls and channel bottom should be repaired. Undercutting of the channel floor if left unchecked could lead to the potential failure of the spillway structure. Brush and small trees were observed on the upstream and downstream slope. The brush and small trees should be removed in a controlled manner.

The Bentleyville Dam is a significant hazard-small size dam. The recommended spillway design flood (SDF) for a dam of this size and classification is in the range of the 100-year storm to 1/2 PMF. Based on the downstream potential for significant property damage to outlying areas of Bentleyville and Interstate 70, the spillway design flood has been selected as the 1/2 PMF.

The spillway and reservoir are capable of controlling approximately 19% of the PMF without overtopping the embankment low spot. The spillway is capable of controlling the 100-year flood. Based on criteria established by the Corps of Engineers, the spillway is termed inadequate.

The following recommendations and remedial measures should be instituted immediately.

1. It should be ascertained whether the upstream shutoff for the 12" cast iron pipe is operable. If it is found that the valve is not operable, it should be made operable or some other method devised to drain the reservoir. If the valve is operable, it should be operated and lubricated on a regular basis.

2. The wet areas observed on the downstream slope of the dam should be investigated to determine the extent of the seepage, and its affect on the stability of the structure. The investigation should be conducted by a registered professional engineer knowledgeable in dam design and analysis.

3. The spillway is in a deteriorating condition. The concrete in the channel walls and channel bottom should be repaired.

4. A regularly scheduled maintenance and operation plan should be prepared and implemented to check future deterioration of the structure.

5. A warning system should be developed to warn downstream residents of large spillway discharges or imminent failure of the dam.

6. The brush and small trees on the upstream and downstream slopes of the dam should be removed under the direction of a registered professional engineer knowledgeable in dam design and construction, to insure that removal of the vegetation does not seriously affect the stability of the structure.

7. A safety inspection program should be implemented with inspections at regular intervals by qualified personnel.

8. The facilities installed on the spillway crest control structure, for the installation of flashboards should be removed to insure that flashboards are not installed at the structure.

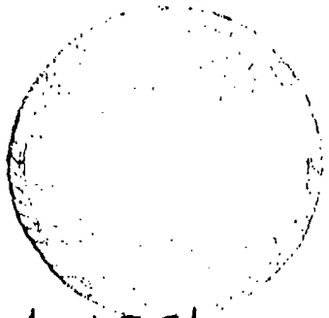
9. The areas on the upstream slope where riprap has been removed should be repaired by replacing the riprap.

10. Areas of observed erosion should be repaired and seeded.

BENTLEYVILLE DAM
PA 1096

SUBMITTED BY:

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS AND ARCHITECTS



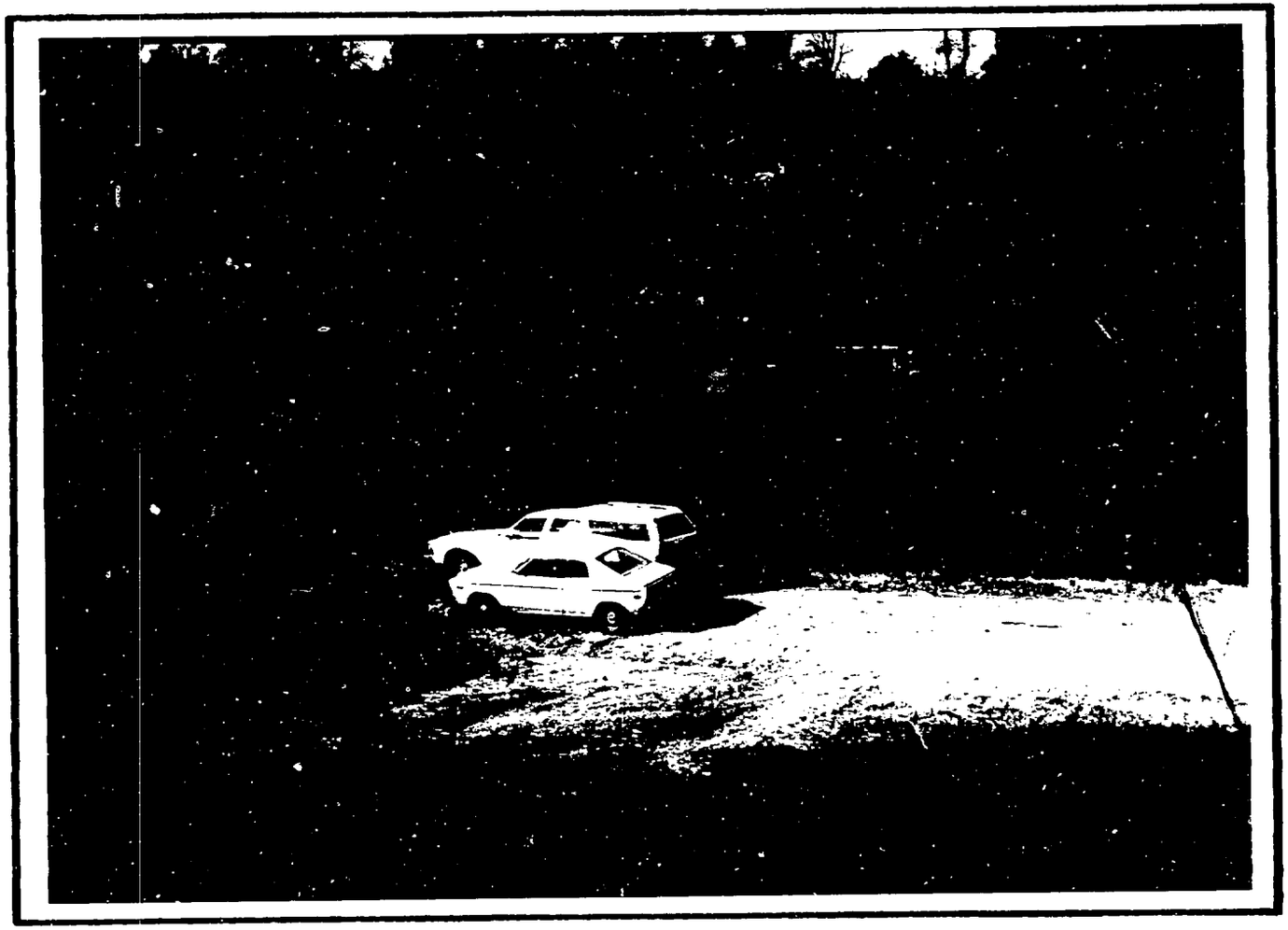
6-15-81
Date

R. Jeffrey Kimball, P.E.

APPROVED BY:

7 JULY 81
Date

JAMES W. PECK
Colonel, Corps of Engineers
Commander and District Engineer



Overview of Bentleyville Dam.

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NATIONAL DAM INSPECTION PROGRAM

BENTLEYVILLE DAM
NDI. I.D. NO. PA 1096
DER I.D. NO. 63-49

SECTION 1
PROJECT INFORMATION

1.1 General.

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose. The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project.

a. Dam and Appurtenances. The Bentleyville Dam is an earthfill dam, 283 feet long (including spillway) and 24 feet high. The crest width of the dam varies, with the majority of the crest being approximately 7 feet in width. The upstream slope of the dam is approximately 2H:1V, and the downstream slope of the dam is 2H:1V.

A concrete control structure exists on the upstream slope of the dam at mid-embankment. The structure houses a gate which controls flow through the drainline.

The spillway for the dam is located at the left abutment. The spillway is rectangular, with concrete retaining walls and a stepped concrete lined discharge channel. The concrete lined channel serves to provide discharges to the stream below the spillway. The width between the spillway sidewalls at the weir is 20 feet, and the depth from the top of these walls to the weir crest is approximately 5 feet. The shape of the weir, however, is such that the effective weir length equals 25 feet.

b. Location. The dam is located on a tributary to Pigeon Creek, approximately 3 miles northwest of Bentleyville, Somerset Township, Washington County, Pennsylvania. The Bentleyville Dam can be located on the Hackett, U.S.G.S. 7.5 minute quadrangle.

c. Size Classification. The Bentleyville Dam is a small size dam (24 feet high, 79 acre-feet).

d. Hazard Classification. The Bentleyville Dam is a significant hazard dam. Outlying areas of Bentleyville and Interstate Route 70 appear susceptible to significant damage should the structure fail.

e. Ownership. The Bentleyville Dam is owned by Bentleyville Water Authority. Correspondence should be addressed to:

The Bentleyville Water Authority
513 Main Street
Bentleyville, Pennsylvania 15314
412/239-2381

f. Purpose of Dam. The dam was originally constructed for the purposes of supplying water for the Borough of Bentleyville. The Borough of Bentleyville has since abandoned the dam as a water supply, and the dam presently serves no useful purpose to the Borough.

g. Design and Construction History. Based on information contained in the PennDER files, it appears as though the construction of the dam began in mid-1938. The design of the dam was completed by the Chester Engineers of Pittsburgh, Pennsylvania. No information was available relative to construction of the dam.

h. Normal Operating Procedures. The reservoir is currently maintained at the spillway crest elevation. No operations have been conducted at the dam for many years. It was reported by Mr. Bernard Crumline (Superintendent, Bentleyville Water Authority), that the Borough discontinued using water from the reservoir around 1964 or 1965.

1.3 Pertinent Data.

a. Drainage Area. 1.2 square miles

b. Discharge at Dam Site (cfs).

Maximum known flood at dam site	Unknown
Drainline capacity at normal pool	Unknown
Spillway capacity at top of dam (low spot)	630

c. Elevation (feet) . - Field survey based on elevation of left spillway wall, elevation 1018.0. Design drawings indicate difference in elevations relative to U.S.G.S. Datum and Field measurements taken during the inspection.

Top of dam - low point	1017.8
Top of dam - design height	1018.75
Pool at time of inspection	1013.1
Spillway crest	1013.1

Note: Elevations used in this report were based on design drawings (Appendix E) and do not correlate with U.S.G.S. datum.

Maximum pool - design surcharge	Unknown
Full flood control pool	N/A
Normal pool	1013.1
Upstream portal - 12" CIP	Unknown
Downstream portal - 12" CIP	994.3
Streambed at centerline of dam	Unknown
Maximum tailwater	Unknown
Toe of dam	994.3

d. Reservoir (feet).

Length of maximum pool	2500
Length of normal pool	1300

e. Storage (acre-feet).

Normal pool (spillway crest)	30
Top of dam	79

f. Reservoir Surface (acres).

Top of dam - low spot	17
Normal pool	5.5
Spillway crest	5.5

g. Dam.

Type	Earthfill
Length (including spillway)	283 feet
Height	24 feet
Top width	7 feet
Side slopes - upstream	2H:1V
- downstream	2H:1V
Zoning	Yes
Impervious core	No
Cutoff	Partial
Grout curtain	None

h. Reservoir Drain.

Type	12" diameter CIP
Length (through embankment)	50 feet
Closure (upstream)	Gate housed in Control structure
Closure (downstream)	12" gate valve on downstream end of pipe

Access	Upstream slope (Control structure) Downstream valve exposed
Regulating facilities	Control structure on upstream slope equipped with stem

i. Spillway.

Type	Rectangular with an irregular shaped weir
Length (effective crest length)	25 feet
Crest elevation	1013.1
Upstream channel	Lake (unrestricted)
Downstream channel	Tributary to the North Branch of Pigeon Creek

SECTION 2
ENGINEERING DATA

2.1 Design. Review of available information in the files of the Commonwealth of Pennsylvania, Department of Environmental Resources, revealed that some correspondence, permit information, design drawings and pictures were available for review. Pertinent design drawings relative to the design of the Bentleyville Dam are located in Appendix E of this report.

2.2 Construction. No information was available regarding the construction of the dam.

2.3 Operation. No operations are presently conducted at the dam.

2.4 Evaluation.

a. Availability. Engineering data were provided by the PennDER, Bureau of Dams and Waterway Management. The superintendent of the Bentleyville Water Authority, Mr. Bernard Crumrine, was interviewed to obtain data relative to the dam. Mr. Crumrine did not supply any additional information.

b. Adequacy. This Phase I Report is based on the visual inspection, hydrologic and hydraulic analysis. Sufficient information exists to complete a Phase I Report.

SECTION 3
VISUAL INSPECTION

3.1 Findings.

a. General. The on site inspection of Bentleyville Dam was conducted by personnel of L. Robert Kimball and Associates accompanied by Mr. Bernard Crumrine (Superintendent, Bentleyville Water Authority), on November 5, 1980 and May 12, 1981. The inspection consisted of:

1. Visual inspection of the retaining structure, abutments and toe.
2. Examination of the spillway facilities, exposed portion of any outlet works and other appurtenant works.
3. Observations affecting the runoff potential of the drainage basin.
4. Evaluation of the downstream area hazard potential.

b. Dam. The dam appears to be in poor condition. From a brief survey conducted during the inspection, it was noted that the low spot on the crest of the dam was located approximately 50 feet from the spillway. Riprap was observed on the upstream slope of the structure, and it was noted that some riprap was missing in several areas. The crest and slopes of the dam were grass covered. Brush and small trees were observed on both the upstream and downstream slopes. A small erosion area was observed adjacent to the right spillway wingwall. Wet areas were observed on the downstream slope adjacent to the right abutment contact, and a small wet area was observed on the downstream slope adjacent to the right spillway discharge channel wall, approximately 10 feet below the crest of the dam. No visible flow was observed at either wet area.

c. Appurtenant Structures. The spillway for the dam is located at the left abutment of the structure. An abandoned foot bridge spans the spillway crest. The spillway was constructed of concrete and incorporated a step type design in the discharge channel. In general, the existing concrete in the spillway is in a deteriorating condition. In several areas along the spillway channel walls and spillway bottom, the concrete has deteriorated to such an extent that reinforcing steel was observed. Sections of the stepped concrete channel bottom have deteriorated to an extent that undercutting of the channel floor is occurring due to seepage under the concrete lining.

An irregular shaped concrete weir exists at the entrance to the spillway, and serves as the control structure. The channel width at the control section, between the spillway retaining walls, is 20 feet. The configuration of the control section is such that the effective length of the weir is 25 feet. Steel bars exist along the crest of the control section and are utilized for the placement of flashboards. Only one flashboard was observed on the crest of the control section during the November 5, 1980 inspection. No flashboards were observed during the May 12, 1981 inspection.

The drainline control structure located on the upstream slope of the dam was observed to be in a deteriorating condition. An abandoned foot bridge serves as access to the control structure. The control for the gate valve housed in the control structure was observed to be very badly rusted, and apparently not capable of serving to control the valve. The valve on the downstream end of the drainline was visible, and the valve was in the open position. No flow was observed discharging from the line.

d. Reservoir Area. The watershed was observed as being covered almost equally with forested lands and open fields. The reservoir slopes are moderate to steep, but do not appear to be susceptible to landslides which would affect the storage volume of the reservoir or overtopping of the dam by displacing water.

e. Downstream Channel. The downstream channel for the Bentleyville Dam consists of a tributary to the North Branch of Pigeon Creek. Interstate Route 70 is located approximately 1,000 feet downstream of the dam, and the Borough of Bentleyville is located approximately 3 miles downstream.

3.2 Evaluation. In general, the dam and appurtenant structures appear to be in poor condition. No major erosion or seepage areas were observed during the inspection. Wet areas were observed on the downstream slope near the right abutment contact and adjacent to the right spillway wingwall approximately 10 feet below the crest. The wet areas should be monitored. The brush and small trees on the slopes of the dam should be removed under the direction of a registered professional engineer knowledgeable in dam design and construction. The drainline control at the upstream end of the drainline appeared to be inoperative. The concrete in the spillway channel walls and channel bottom is in a deteriorating condition and should be repaired.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures. The reservoir is maintained at the spillway crest elevation. No other procedures are conducted at the dam.

4.2 Maintenance of the Dam. Maintenance of the dam is considered poor. No planned maintenance schedule exists for the dam.

4.3 Maintenance of Operating Facilities. There is no maintenance of the operating facilities.

4.4 Warning System in Effect. There is no warning system in effect to warn downstream residents of large spillway discharges or imminent failure of the dam.

4.5 Evaluation. No maintenance of the dam or operating facilities is conducted. Brush and small trees have been allowed to grow on the slopes of the structure. The concrete in the spillway discharge channel and spillway retaining walls is in a deteriorating condition. The control structure on the upstream slope of the dam, which houses the control for the drainline is in a deteriorating condition. The control is rusted, and apparently inoperable.

An emergency action plan should be available for every dam in the high and significant category. Such plans should outline actions to be taken by the operator to minimize downstream affects of an emergency, and should include an effective warning system. No emergency action plan has been developed, and the owner should develop such a plan.

SECTION 5
HYDRAULICS AND HYDROLOGY

5.1 Evaluation of Features.

a. Design Data. Limited information relative to the hydraulic design of the spillway was available for review. The available data listed the effective weir length at 27 feet, and it was noted that the spillway was capable of discharging in excess of 900 cfs. No detailed hydraulic design was available for review.

b. Experience Data. No rainfall, runoff or reservoir level data were available. The spillway reportedly has functioned adequately in the past.

c. Visual Observations. The spillway appeared to be in poor condition and inadequately maintained. The spillway is in a deteriorating condition, but the deterioration does not appear to be capable of hampering discharges through the channel. The control section appeared to be in fair condition. The effective length of the control section was observed to be greater than that between the spillway wingwalls.

The low spot on the embankment crest was observed at approximately 50 feet right of the spillway.

d. Overtopping Potential. Overtopping potential was investigated through the development of the probable maximum flood (PMF) for the watershed and the subsequent routing of the PMF and fractions of the PMF through the reservoir and spillway.

The Corps of Engineers, Baltimore District, has directed that the HEC-1 Dam Safety Version systemized computer program be utilized. The program was prepared by the Hydrologic Engineering Center (HEC), U.S. Army Corps of Engineers, Davis, California, July 1978. The major methodologies or key input data for this program are discussed briefly in Appendix D.

5.2 Evaluation Assumptions. To enable completion of the hydraulic and hydrologic analysis for this structure, it was necessary to make the following assumptions.

1. The pool elevation in the reservoir prior to the storm was assumed to be at the spillway crest elevation, 1013.1.

2. The top of dam was considered to be the low spot elevation, 1017.8.

3. The effective low head weir length for the spillway control section was considered to be 25 feet. Flashboards were considered as being nonexistent. The metal posts on the spillway crest were not considered in the analysis.

5.3 Summary of Overtopping Analysis. Complete summary sheets for the hydraulic and hydrologic analysis and computer output are presented in Appendix D.

Peak inflow (100-year storm)	525 cfs
Peak inflow (0.5 PMF)	1696 cfs
Spillway capacity	630 cfs

a. Spillway Adequacy Rating. The Spillway Design Flood (SDF) is based on the hazard and size classification of the dam. The recommended spillway design flood for a dam of this size and classification is in the range of the 100-year storm to the 1/2 PMF. Based on the downstream potential for significant property damages to outlying areas of Bentleyville and Interstate Route 70, the spillway design flood has been selected as the 1/2 PMF. Based on the following definition provided by the Corps of Engineers, the spillway is rated as inadequate as a result of our hydrologic analysis.

> Inadequate - All significant hazard dams which do not pass the spillway design flood (1/2 PMF).

The spillway and reservoir are capable of controlling the 100-year storm and approximately 19% of the PMF without overtopping the embankment.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability.

a. Visual Observations. No major erosion areas were observed on the embankment crest or slopes. A small erosion area was observed on the crest adjacent to the right spillway wingwall. No measureable seepage was observed during the inspection. Two wet areas were observed on the downstream slope of the dam. One wet area was observed near the right abutment contact, and the second wet area was observed on the downstream slope adjacent to the right spillway discharge channel wall, approximately 10 feet below the crest. Small trees and brush were observed on the upstream and downstream slopes of the dam.

b. Design and Construction Data. Only limited information was available in the DER files relative to the construction of the dam. Available information indicates that the embankment was constructed of select material on the upstream slope, with common borrow material being utilized on the downstream half of the dam. Design drawings indicate that a puddle trench was to be constructed along the entire length of the dam, with three puddle trenches carried to a depth of at least 12 inches into impervious material. A July 13, 1938 progress report, submitted by an engineer representing the Department of Forest and Waters reported on the progress of construction as of July 5th of the same year. It was noted in the memorandum that three puddle trenches had been excavated in accordance with plans. The two outside trenches were 18" wide and ranged in depth from 3' to about 8'. Between the two outside trenches, the main puddle trench was 3' wide and also ranged to a depth of 3' to 8'. It was also noted that the three trenches were on the upstream side of the centerline of the dam, being spaced about 20 feet apart and converged into a single trench at each end of the dam. The progress report continued stating that blowoff pipe was in-place and covered. It was reported that only three of the four collars had been placed around the pipe. The inspecting engineer asked that the additional collar be placed in the main puddle trench as shown on plan, and that it be left exposed for inspection.

The dam was designed by the Chester Engineers of Pittsburgh, Pennsylvania. Pertinent design drawings are available in Appendix E. It appears as though construction of the dam began in mid-1938, and a September 26, 1938 memorandum indicates that the project was complete about the middle of August 1938.

c. Operating Records. No operating records exist for the dam.

d. Post Construction Changes. No post construction changes are known to have occurred since construction of the dam was completed in 1938.

e. Evaluation. No major deficiencies were observed during the inspection which were considered as having an immediate effect on the static stability of the structure. Wet areas observed on the downstream slope should be evaluated as to possible affect on stability. The dam is assumed statically stable.

It should be noted that mining may have occurred beneath the dam, and the owner should be aware of possible subsidence in the area of the dam and the potential effects relative to the ongoing stability of the structure.

f. Seismic Stability. The dam is located in seismic zone 1. No seismic stability analyses have been performed. Normally, it can be considered that if a dam in this zone is stable under static loading conditions, it can be assumed safe for any expected earthquake loading. Since the dam is assumed to be statically stable at the present time, the dam is assumed safe for earthquake loadings. No calculations were performed to document this assumption.

SECTION 7
ASSESSMENT AND RECOMMENDATIONS/REMEDIAL MEASURES

7.1 Dam Assessment.

a. Safety. In general, the dam appears to be in poor condition and inadequately maintained. The dam and appurtenant structures are in a generally deteriorating condition. No major erosion was observed on the slopes or crest of the dam. A small erosion area was observed adjacent to the right spillway wingwall on the crest of the dam. It was observed during the inspection that several small areas of riprap had been removed from the upstream slope of the dam. The inspection of the drainline control valve stem revealed that the control was badly rusted, and apparently inoperable. Two valves exist on the drainline. The downstream valve was observed to be opened and no flow was observed discharging from the pipe. The upstream valve was apparently closed.

Two wet areas were observed on the downstream slope of the dam. At the time of the inspections, no flow was observed from the areas. The seepage should be investigated to ascertain its effects on the stability of the structure. The concrete in the spillway is in a deteriorating condition. Undercutting of the channel bottom is occurring and if left unchecked, continued undercutting in this spillway channel could lead to a potential failure of the structure.

The Bentleyville Dam is a significant hazard-small size dam. The recommended spillway design flood (SDF) for a dam of this size and classification is in the range of the 100-year storm to 1/2 PMF. Based on the downstream potential for significant property damage to outlying areas of Bentleyville and Interstate 70, the spillway design flood has been selected as the 1/2 PMF.

The visual observations, review of available data, hydrologic and hydraulic calculations and past operational performance indicate that the Bentleyville Dam is controlling approximately 19% of the PMF. An analysis of the 100-year storm indicates that the spillway is capable of discharging the storm without overtopping the embankment. The spillway is termed inadequate.

b. Adequacy of Information. Sufficient information is available to complete a Phase I report.

c. Urgency. The recommendations suggested below should be implemented as soon as possible.

d. Necessity for Further Investigation. In order to accomplish some of the recommendations/remedial measures outlined below, further investigations will be required by a professional engineer knowledgeable in dam design and construction.

7.2 Recommendations/Remedial Measures.

1. It should be ascertained whether the upstream shutoff for the 12" cast iron pipe is operable. If it is found that the valve is not operable, it should be made operable or some other method devised to drain the reservoir. If the valve is operable, it should be operated and lubricated on a regular basis.

2. The wet areas observed on the downstream slope of the dam should be investigated to determine the extent of the seepage, and its effect on the stability of the structure. The investigation should be conducted by a registered professional engineer knowledgeable in dam design and analysis.

3. The spillway is in a deteriorating condition. The concrete in the channel walls and channel bottom should be repaired.

4. A regularly scheduled maintenance and operation plan should be prepared and implemented to check future deterioration of the structure.

5. A warning system should be developed to warn downstream residents of large spillway discharges or imminent failure of the dam.

6. The brush and small trees on the upstream and downstream slopes of the dam should be removed under the direction of a registered professional engineer knowledgeable in dam design and construction, to insure that removal of the vegetation does not seriously affect the stability of the structure.

7. A safety inspection program should be implemented with inspections at regular intervals by qualified personnel.

8. The facilities installed on the spillway crest control structure for the installation of flashboards should be removed to insure that flashboards are not installed at the structure.

9. The areas on the upstream slope where riprap has been removed should be repaired by replacing the riprap.

10. Areas of observed erosion should be repaired and seeded.

APPENDIX A
CHECKLIST, VISUAL INSPECTION, PHASE I

CHECK LIST
VISUAL INSPECTION
PHASE I

NAME OF DAM Bentleyville Dam COUNTY Washington STATE Pennsylvania ID# 1096

TYPE OF DAM Earthfill HAZARD CATEGORY Significant

DATE(s) INSPECTION November 5, 1980 WEATHER Clear and cold TEMPERATURE 35°
May 12, 1981 Clear and warm 60°

POOL ELEVATION AT TIME OF INSPECTION 1013.1 M.S.L. TAILWATER AT TIME OF INSPECTION 994.3 M.S.L.

INSPECTION PERSONNEL:

R. Jeffrey Kimball, P.E. - L. Robert Kimball and Associates

James T. Hockensmith - L. Robert Kimball and Associates

O.T. McConnell - L. Robert Kimball and Associates

Bernard Grumrine - Superintendent, Bentleyville Water Authority

O.T. McConn[illegible] RECORDER

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None noted.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None noted.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Minor erosion area observed on the crest adjacent to the right spillway retaining wall.	The erosion area should be repaired.
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Appears to be all right.	
RIPRAP FAILURES	Riprap missing on upstream slope in several locations.	The riprap should be replaced.

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
VEGETATION	Brush and small trees exist on the upstream and downstream slopes.	The brush and trees should be removed.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Appears to be all right, except for a minor area on the crest adjacent to the right spillway retaining wall.	The erosion area should be repaired.
ANY NOTICEABLE SEEPAGE	Two wet areas were observed on the downstream slope of the dam. One erosion area was observed at the right abutment contact, and a second wet area was observed on the downstream slope adjacent to the right spillway channel wall, approximately 10 feet below the crest.	No flow was observed during either inspection, but the seepage should be investigated.
STAFF GAUGE AND RECORDER	None.	
DRAINS	None.	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	Not applicable.	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	Not applicable.	
DRAINS	Not applicable.	
WATER PASSAGES	Not applicable.	
FOUNDATION	Not applicable.	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	Not applicable.	
STRUCTURAL CRACKING	Not applicable.	
VERTICAL AND HORIZONTAL ALIGNMENT	Not applicable.	
MONOLITH JOINTS	Not applicable.	
CONSTRUCTION JOINTS	Not applicable.	
STAFF GAUGE OR RECORDER	Not applicable.	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Not applicable.	
INTAKE STRUCTURE	Concrete structure on the upstsream slope of the dam. 12" gate valve controlled by a stem to the top of the structure.	
OUTLET STRUCTURE	Exposed pipe with a 12" gate valve in the open position.	
OUTLET CHANNEL	Natural stream below the dam.	
EMERGENCY GATE	12" gate valves on upstream and downstream end of line.	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	The spillway control section appeared to be in fair condition. One flashboard existed on the crest during the November 5, 1980 inspection. During the May 12, 1981 inspection the flashboard was not in place.	The metal posts, which exists on the crest of the spillway control section, should be removed to insure that flashboards are not used at the facility.
APPROACH CHANNEL	Lake [unrestricted].	
DISCHARGE CHANNEL	Concrete discharge channel with step type construction.	The discharge channel is in a deteriorating condition. Undercutting is occurring on the channel floor due to discharges seeping beneath the concrete.
BRIDGE AND PIERS	An abandoned foot bridge spans the spillway crest area.	

GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	Not applicable.	
APPROACH CHANNEL	Not applicable.	
DISCHARGE CHANNEL	Not applicable.	
BRIDGE AND PIERS	Not applicable.	
GATES AND OPERATION EQUIPMENT	Not applicable.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	The spillway discharge channel for the Bentleyville Dam consists of a tributary to the North Branch of Pigeon Creek. No obstructions or debris were observed in the channel.	Interstate 70 is located approximately 1000 feet downstream of the dam.
SLOPES	Appear to be stable.	
APPROXIMATE NO. OF HOMES AND POPULATION	The Borough of Bentleyville is located approximately 3 miles southeast of the dam. The population of the Borough of Bentleyville and outlying areas is estimated at approximately 600 people.	

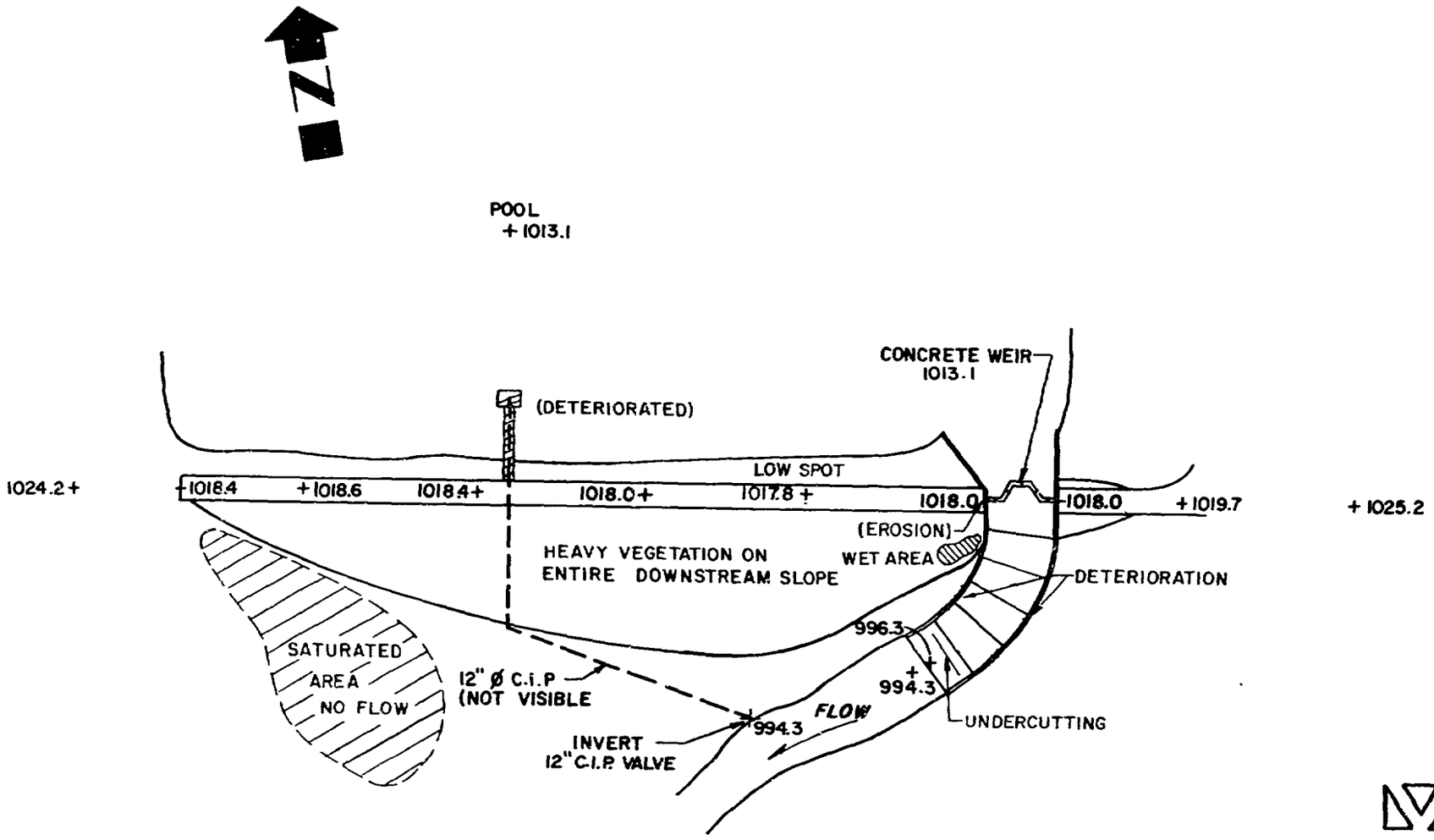
RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Moderate to steep, appear to be stable.	
SEDIMENTATION	Unknown.	

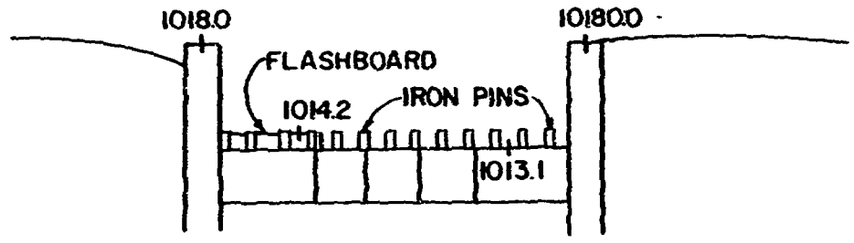
INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None.	
OBSERVATION WELLS	None.	
WEIRS	None.	
PIEZOMETERS	None.	
OTHER	None.	

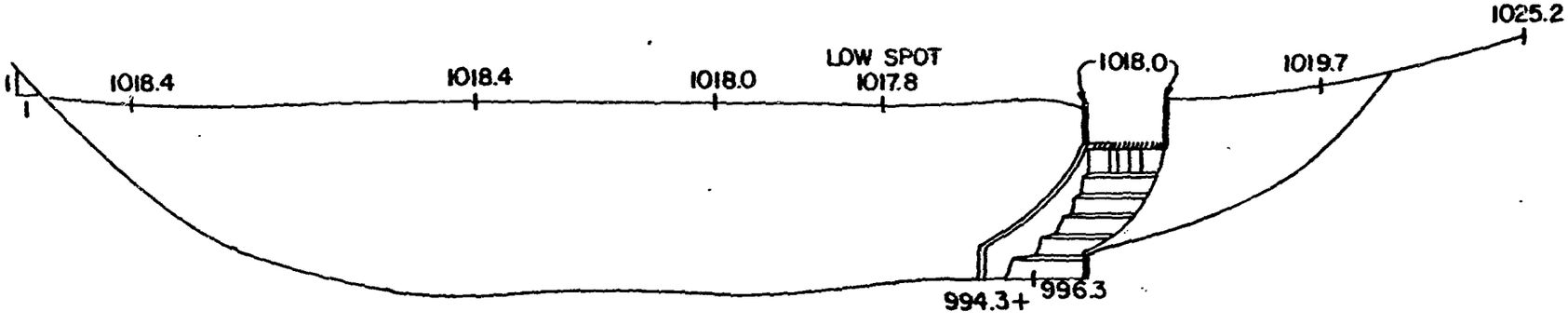
A-12



BENTLEYVILLE DAM
SCALE: 1" = 45'
(APPROX.)



SPILLWAY CREST
LOOKING UPSTREAM
SCALE: 1"=10'



PROFILE
LOOKING UPSTREAM
SCALE: HORIZ. 1"=40'
VERT. 1"=20'

BENTLEYVILLE DAM

A-13

APPENDIX B
CHECKLIST, ENGINEERING DAT.., DESIGN, CONSTRUCTION, OPERATION, PHASE I

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM Bentleyville Dam

ID# PA 1096

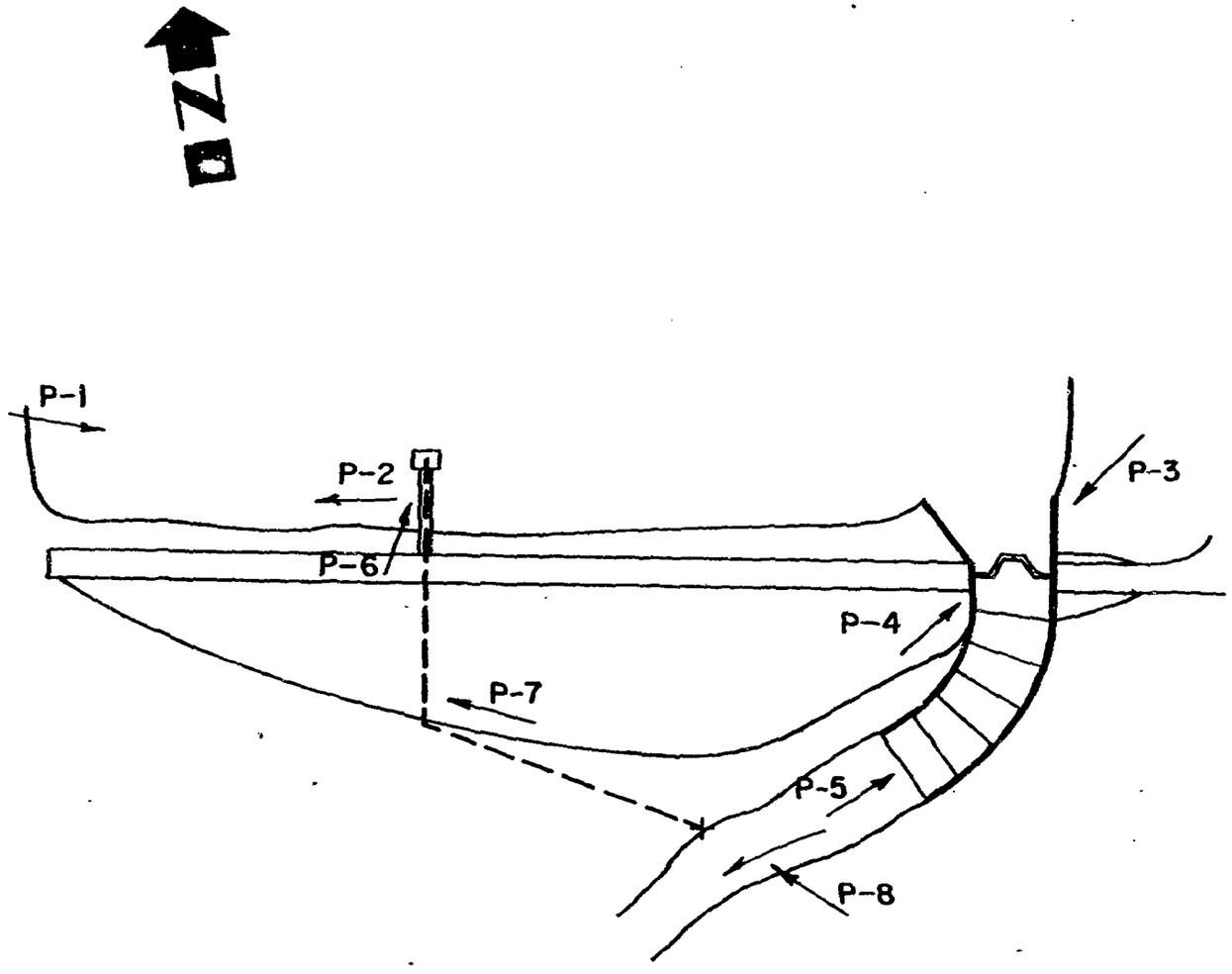
ITEM	REMARKS
AS-BUILT DRAWINGS	None.
REGIONAL VICINITY MAP	U.S.G.S. 7.5 minute quadrangle.
CONSTRUCTION HISTORY	Limited information available in DER files.
TYPICAL SECTIONS OF DAM	See Appendix E.
OUTLETS - PLAN - DETAILS - CONSTRAINTS - DISCHARGE RATINGS RAINFALL/RESERVOIR RECORDS	See Appendix E. See Appendix E. See Appendix E. None. None.

ITEM	REMARKS
DESIGN REPORTS	None available.
GEOLOGY REPORTS	None available.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None available.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	None. Test pits, see Appendix E, [E-2]. None.
POST-CONSTRUCTION SURVEYS OF DAM	None known to have occurred.
BORROW SOURCES	Unknown.

ITEM	*REMARKS*
MONITORING SYSTEMS	None.
MODIFICATIONS	None known to exist since construction of the structure.
HIGH POOL RECORDS	None.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None known to exist.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None known to have occurred.
MAINTENANCE OPERATION RECORDS	None.

ITEM	REMARKS
SPILLWAY PLAN SECTIONS DETAILS	See Appendix E.
OPERATING EQUIPMENT PLANS & DETAILS	See Appendix E.

APPENDIX C
PHOTOGRAPHS



C-1

BENTLEYVILLE DAM
PHOTO INDEX

P- INDICATES PHOTO LOCATION

BENTLEYVILLE DAM
PA 1096

Sheet 1

Front

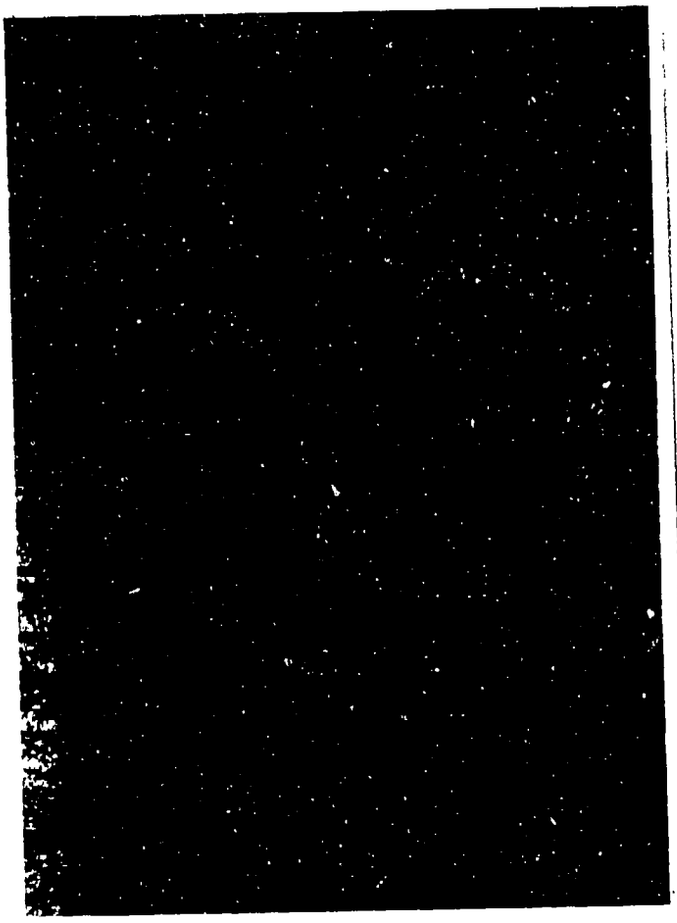
1. Upper left - Overview of upstream slope of dam, drainline control structure, and spillway approach. View towards the left abutment.
2. Upper right - View of upstream slope. View towards the right abutment. Note brush and small tree on upstream slope, and partial view of riprap.
3. Lower left - View of spillway approach, and spillway control section. Note existance of one flashboard and abandoned foot bridge which spans the spillway crest.
4. Lower right - Close-up of spillway control structure. Note facilities for installation of flashboards.

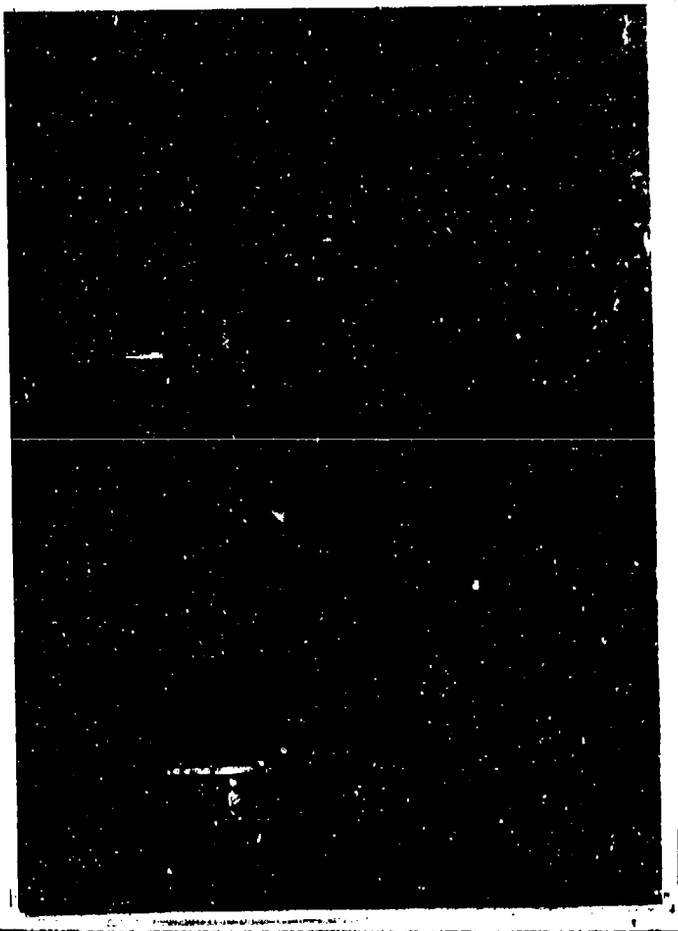
Back

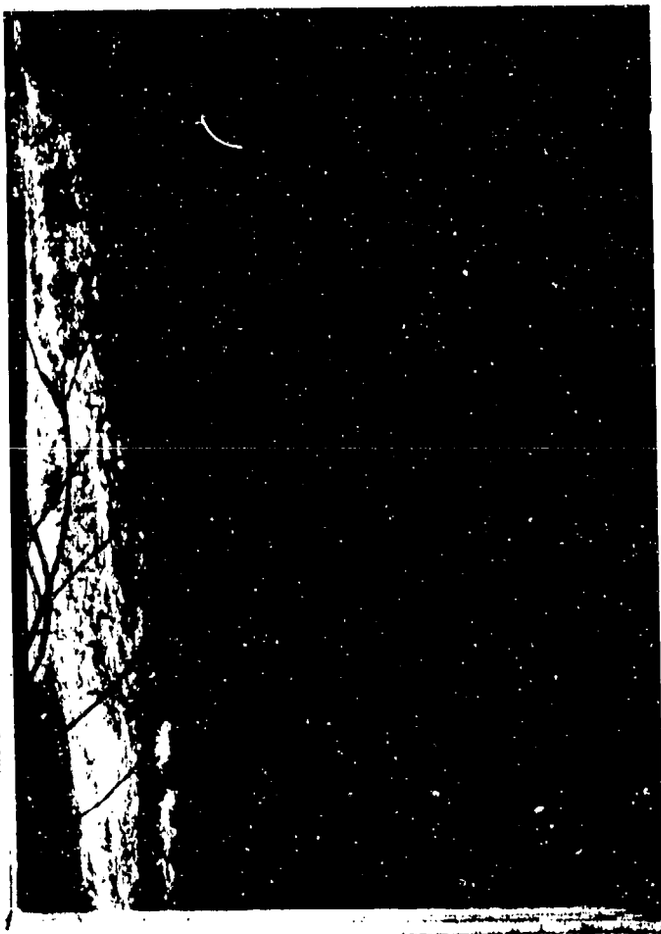
5. Upper left - View of spillway discharge channel. Note deterioration of concrete, and undercutting.
6. Upper right - View of drainline control structure on upstream slope. Note deterioration of abandoned foot bridge.
7. Lower left - View of seepage area on downstream slope at the left abutment contact.
8. Lower right - View of 12" gate valve at downstream end of drainline.

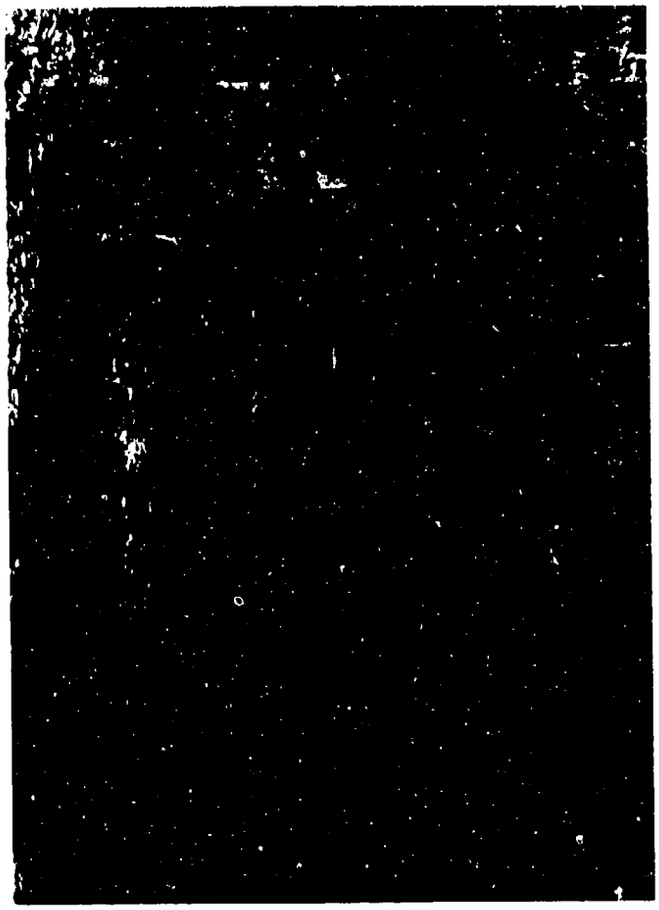
TOP OF PAGE

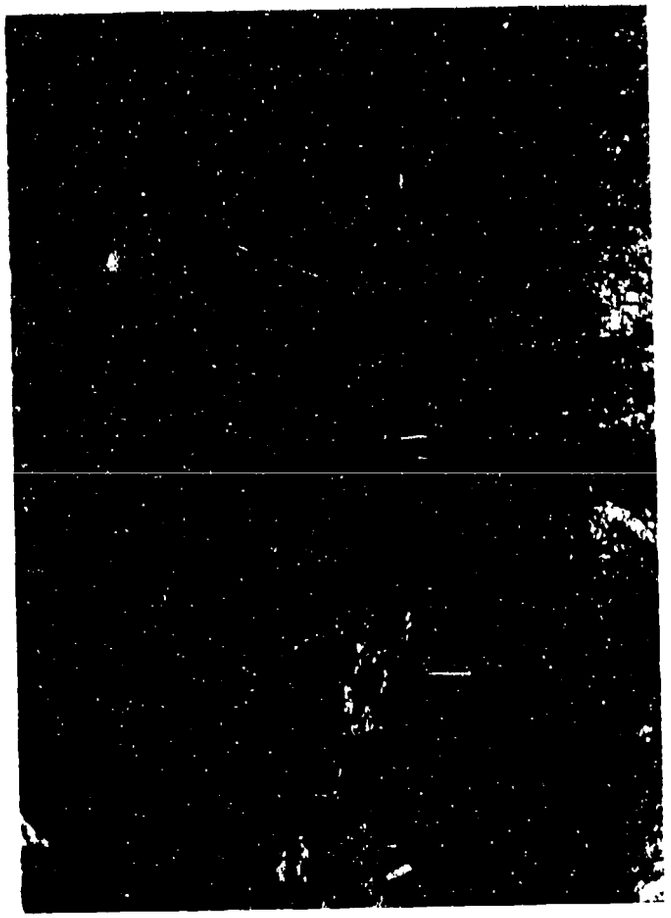
1,5	2,6
3,7	4,8

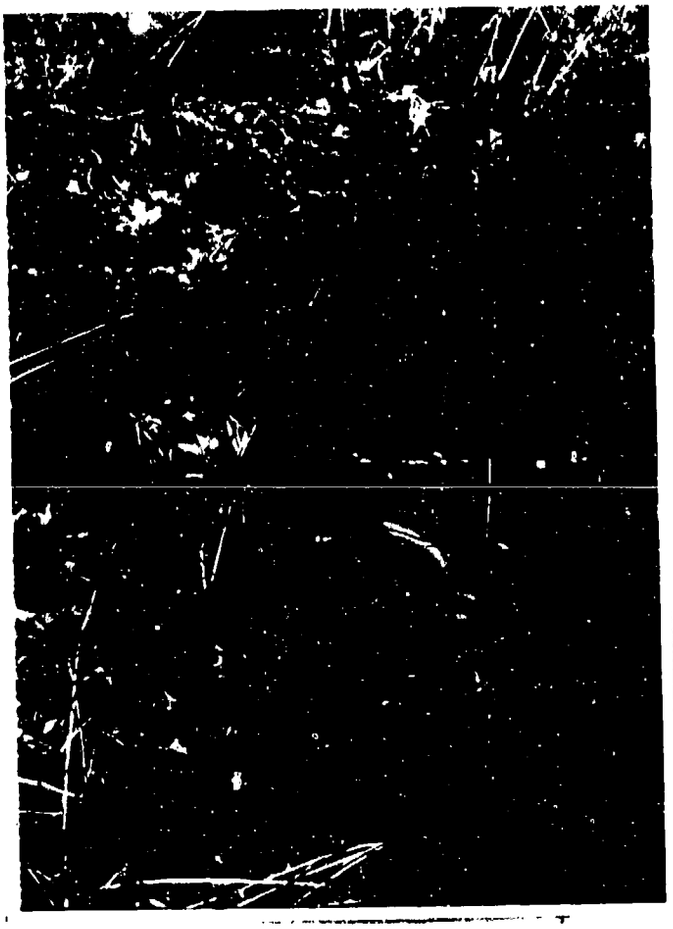












APPENDIX D
HYDROLOGY AND HYDRAULICS

APPENDIX D
HYDROLOGY AND HYDRAULICS

Methodology. The dam overtopping and breach analyses were accomplished using the systemized computer program HEC-1 (Dam Safety Investigation), September, 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California. A brief description of the methodology used in the analysis is presented below.

1. Precipitation. The Probable Maximum Precipitation (PMP) is derived and determined from regional charts prepared from past rainfall records including "Hydrometeorological Report No. 33" prepared by the U.S. Weather Bureau.

The index rainfall may be reduced from 10% to 20% depending on watershed size by utilization of what is termed the HOP Brook adjustment factor. Distribution of the total rainfall is made by the computer program using distribution methods developed by the Corps.

2. Inflow Hydrograph. The hydrologic analysis used in development of the overtopping potential is based on applying a hypothetical storm to a unit hydrograph to obtain the inflow hydrograph for reservoir routing.

The unit hydrograph is developed using the Snyder method. This method requires calculation of several key parameters. The following list gives these parameters their definition and how they were obtained for these analysis.

Parameter	Definition	Where Obtained
Ct	Coefficient representing variations of watershed	From Corps of Engineers*
L	Length of main stream channel miles	From U.S.G.S. 7.5 minute topgraphic
Lca	Length on main stream to centroid of watershed	From U.S.G.S. 7.5 minute topographic
Cp	Peaking coefficient	From Corps of Engineers*
A	Watershed size	From U.S.G.S. 7.5 minute topographic

*Developed by the Corps of Engineers on a regional basis for Pennsylvania.

3. Routing. Reservoir routing is accomplished by using Modified Plus routing techniques where the flood hydrograph is routed through reservoir storage. Hydraulic capacities of the outlet works, spillways and the crest of the dam are used as outlet controls in the routing.

The hydraulic capacity of the outlet works can either be calculated and input, or sufficient dimensions input, and the program will calculate an elevation discharge relationship.

Storage in the pool area is defined by an area - elevation relationship from which the computer calculates storage. Surface areas are either planimetered from available mapping or U.S.G.S. 7.5 minute series topographic maps or taken from reasonably accurate design data.

4. Dam Overtopping. Using given percentages of the PMF, the computer program will calculate the percentage of the PMF, which can be controlled by the reservoir and spillway without the dam overtopping.

5. Dam Breach and Downstream Routing. The computer program is equipped to determine the increase in downstream flooding due to failure of the dam caused by overtopping. This is accomplished by routing both the pre-failure peak flow and the peak flow through the breach (calculated by the computer with given input assumptions) at a given point in time and determining the water depth in the downstream channel. Channel cross-sections taken from U.S.G.S. 7.5 minute topographic maps were used in the downstream flood wave routing. Pre and post failure water depths are calculated at locations where cross-sections are input.

HYDROLOGY AND HYDRAULICS ANALYSIS
DATA BASE

NAME OF DAM: Bentleyville Dam

PROBABLE MAXIMUM PRECIPITATION (PMP) = 24.3 inches

STATION	1	2	3
Station Description	Bentleyville		
Drainage Area (square miles)	1.2		
Cumulative Drainage Area (square miles)	1.2		
Adjustment of PMF for Drainage Area (%)(1)	(Zone 7)		
6 hours	102		
12 hours	120		
24 hours	130		
48 hours	140		
72 hours	N/A		
Snyder Hydrograph Parameters			
Zone (2)	29		
Cp (3)	0.50		
Ct (3)	1.6		
L (miles) (4)	1.89 miles		
Lca (miles) (4)	0.95		
tp = Ct(LxLca) 0.3 hrs.	1.91		
Spillway Data			
Crest Length (ft)	25 (effective length for low heads)		
Freeboard (ft)	4.7		
Discharge Coefficient	3.1		
Exponent	1.5		

(1) Hydrometeorological Report 33 (Figure 1), U.S. Weather Bureau and U.S. Army Corps of Engineers, 1956.
(2) Hydrological zone defined by Corps of Engineers, Baltimore District, for determining Snyder's coefficients (C_p and C_t).
(3) Snyder's Coefficients.
(4) L=Length of longest water course from outlet to basin divide.
L_{ca}=Length of water course from outlet to point opposite the centroid of drainage area.

CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 1.2 sq.miles

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 1013.1 [30 ac-ft]

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 1017.8 [79 ac-ft]

ELEVATION MAXIMUM DESIGN POOL: 1018.5

ELEVATION TOP DAM: 1017.8

SPILLWAY CREST:

a. Elevation 1013.1
b. Type Irregular-semi-sharp crest
c. Width Effective crest length = 25 feet
d. Length Spillway length, approximately 65 feet
e. Location Spillover Left abutment
f. Number and Type of Gates None

OUTLET WORKS:

a. Type 12" cast iron pipe
b. Location Maximum section
c. Entrance inverts Unknown
d. Exit inverts 994.3
e. Emergency drawdown facilities 12" cast iron pipe [operation questionable

HYDROMETEOROLOGICAL GAUGES:

a. Type None
b. Location None
c. Records None

MAXIMUM NON-DAMAGING DISCHARGE: Unknown

NOTE: Elevations from field survey.

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG PENNSYLVANIA

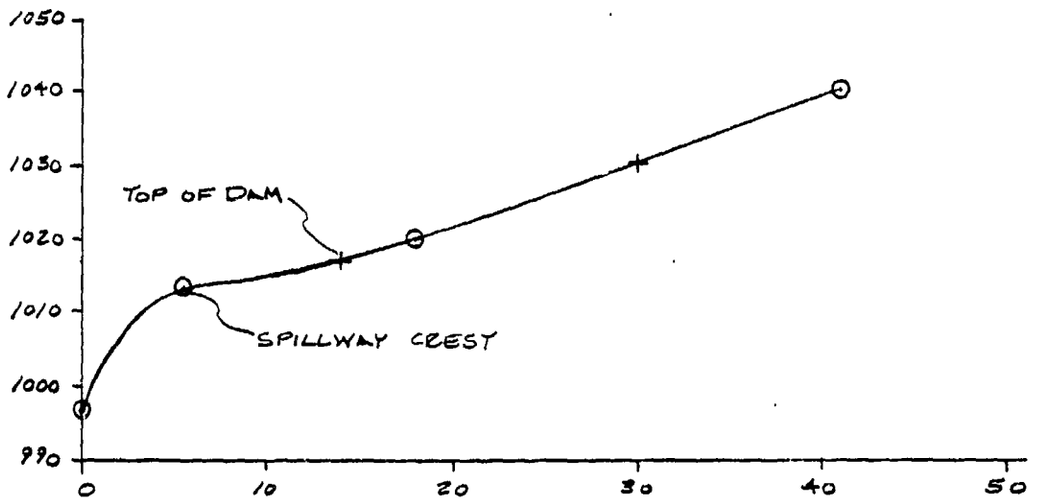
NAME BENTLEYVILLE DAM
NUMBER PA-1096
SHEET NO. 1 OF
BY OTM DATE MAY, 1981

ELEVATION - AREA - CAPACITY RELATIONSHIP

FROM U.S.G.S. 7.5-MIN. QUAD., D.E.R. FILES, AND FIELD INSPECTION DATA.

SPILLWAY CREST AT ELEVATION = 1013.1
SURFACE AREA AT SPILLWAY CREST = 5.5 ACRES
ELEVATION WHERE AREA EQUALS ZERO = 996.6

AT ELEV. 1020, AREA = 18 ACRES
AT ELEV. 1040, AREA = 41 ACRES

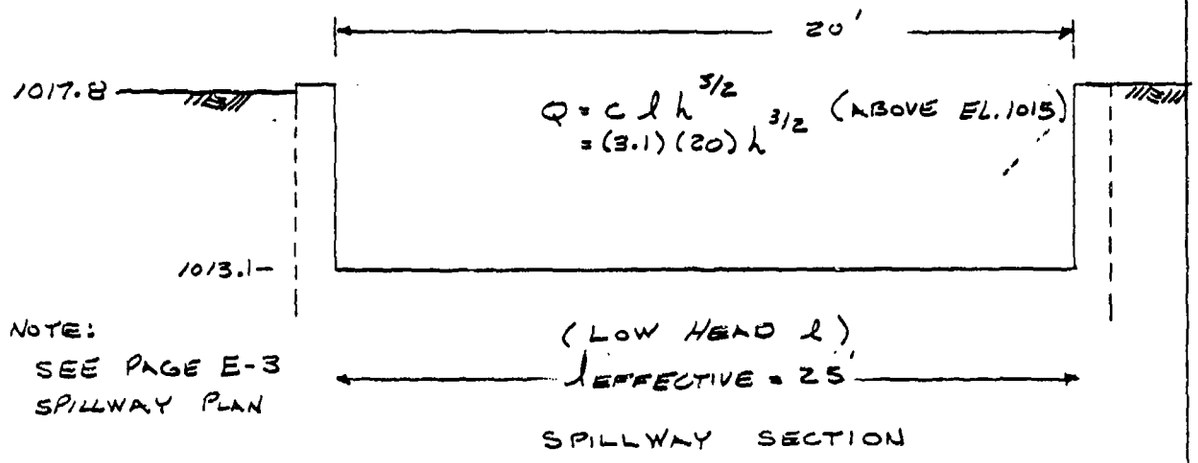


AREA (AC)	0	5.5	14	18	30	41
ELEV. (FT.)	996.6	1013.1	1016.9	1020	1030	1040

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG PENNSYLVANIA

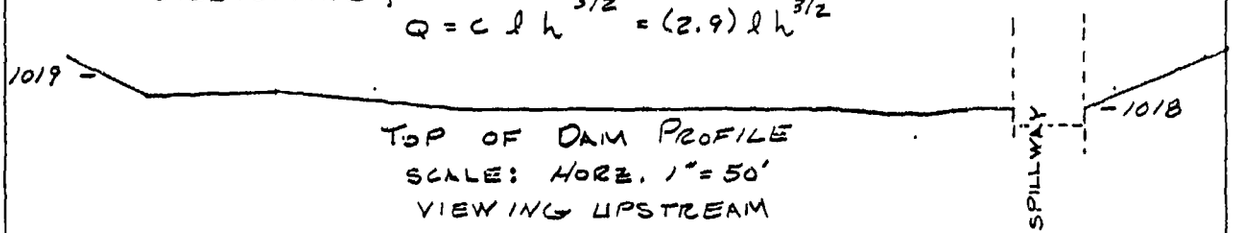
NAME
NUMBER PA-1096
SHEET NO. 2 OF
BY OTM DATE MAY, 1981

DISCHARGE RATING



SPILLWAY SECTION

OVERTOPPING; $Q = c\,l\,h^{3/2} = (2.9)\,l\,h^{3/2}$



TOP OF DAM PROFILE
SCALE: HORZ. 1" = 50'
VIEWING UPSTREAM

ELEV (FT)	SPILLWAY		OVERTOPPING			DISCHARGE
	h (FT)	Q (cfs)	h (FT)	l (FT)	Q (cfs)	*Q (cfs)
1013.1	0	0				0
1013.5	0.4	20				20
1014.0	0.9	65				65
1015.0	1.9	200				200
1016.0	2.9	310				310
1017.8	4.7	630	0	—		630
1018.0	4.9	670	0.2	40	10	680
1018.5	5.4	780	0.7	256	430	1210
1019.0	5.9	890	1.2	270	1030	1920
1019.5	6.4	1000	1.7	290	1860	2860

*Q ROUNDED TO NEAREST 5 c.f.s.

S.D.F. AND FLOOD ROUTING

CONSIDER (1/2 PMF) AS S.D.F. BASED ON DOWNSTREAM CONDITIONS. OUTLYING AREAS OF BENTLEYVILLE, AND INTERSTATE ROUTE 70 APPEAR SUSCEPTIBLE TO SIGNIFICANT DAMAGE SHOULD THE STRUCTURE FAIL. SPILLWAY ADEQUACY TO BE DETERMINED BY (HEC-1).

LOSS RATE AND BASE FLOW PARAMETERS

STRTL = 1 INCH
CNSTL = 0.05 IN/HR
STRTQ = 1.5 cfs/mi^2
QRCSN = 0.05 (5% OF PEAK FLOW)
RTIOR = 2.0

AS RECOMMENDED BY THE BALTIMORE DISTRICT CORPS OF ENGINEERS.

DETERMINATION OF 100-YR FLOOD

OHIO RIVER BASIN, MONONGAHELA SUB-BASIN.

① FROM: MULTIPLE REGRESSION FLOW FREQUENCY

DRAINAGE AREA = 1.2 mi^2
SLOPE = (1260 - 1013)/1.9 = 130 FT/MI
W/L = 1.6/5 = 0.32

FROM $Q_{100} = 193.00\,(D.A. \times S^{1/2})^{0.476198}\,(D.A)^{0.263405}\,(W/L)^{-0.023894}$

$= 193.00(3.47)\,(1.05)\,(1.03)$

$= \underline{723 \text{ cfs}}$

② FROM: WATER RESOURCES BULLETIN No. 13
OCTOBER, 1977

CONSIDER MODEL NO. 5

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG PENNSYLVANIA

NAME
NUMBER PA-1096
SHEET NO. 4 OF
BY OTM DATE MAY, 1981

$Q_{100} = c\, A^{x}\, P_i^{p}$

WHERE:

DRAINAGE AREA (A) = 1.2 mi^2 (USGS 7.5' QUAD)

ANNUAL PRECIPITATION INDEX (P_i) = 40" - 27" = 13"

FROM TABLE 5

$c = 42.2$, $x = 0.751$, $p = 0.744$

$\therefore\ Q_{100} = c\, A^{x}\, P_i^{p}$

$= 42.2\,(1.20)^{0.751}\,(13.0)^{0.744}$

$= \underline{327\ cfs}$

Q_{100} AVERAGE $= \dfrac{Q_{METHOD\ 1} + Q_{METHOD\ 2}}{2}$

$= \dfrac{723 + 327}{2}$

$= \underline{525\ cfs}$

SPILLWAY ADEQUACY (100-YR FLOOD)

ASSUME; INFLOW ≈ OUTFLOW
(SMALL RESERVOIR AREA, S ≈ 0)

SPILLWAY IS ADEQUATE, DAM IS NOT OVERTOPPED. NO DETAILED H&H REQUIRED.

```
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  01 APR 80
*********************************
    1       A1    ANALYSIS OF DAM OVERTOPPING USING RATIOS OF THE PMF
    2       A2    HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF BENTLEYVILLE DAM
    3       A3    RATIOS OF THE PMF ROUTED THROUGH THE RESERVOIR (PA-1096)
    4       B     288       0      10       0       0       0       0       0      -4       0
    5       B1      5
    6       J       1       2       1
    7       J1   [illegible]   1
    8       K       0       1                                        1
    9       K1          INFLOW
   10       M       1       1     1.2                       1                              1
   11       P            24.3     102     120     130     140
   12       T                                                      1.0    0.05
   13       W   [illegible]  [illegible]
   14       X    -1.5    .05      2.0
   15       K       1       2                                        1
   16       K1          ROUTE
   17       Y                               1       1
   18       Y1      1                                          -1013.1      -1
   19       $$[illegible]  1013.5  1014  1015    1016  1017.8    1018  1018.5    1019  [illegible]
   20       Y5      0      20      65     200     310     630     680    1210    1920    2860
   21       $A      0     5.5      14      18      30      41
   22       $E  996.6  1013.1  1016.9    1020    1030    1040
   23       $$1013.1
   24       $D1017.8
```

D-9

FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 01 APR 80

RUN DATE= 81/06/15.
TIME= 04.48.12.

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF THE PMF
HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF BENTLEYVILLE DAM
RATIOS OF THE PMF ROUTED THROUGH THE RESERVOIR (PA-1096)

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
244		10	0	0	0	0	0	94	

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 RATIO= 1 CRITDA= 1

RTIOS= .50 1.00

D-10

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	1.20	0.00	1.20	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	24.30	102.00	120.30	130.00	140.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.50	1.00	1.00	.05	0.00	0.00

UNIT HYDROGRAPH DATA

TRSP= 1691 CP= .50 NTAB= 0

RECESSION DATA

STRTQ= -1.50 QRCSN= -.05 RTIOR= 2.00

UNIT HYDROGRAPH 89 END-OF-PERIOD ORDINATES, LAG= 1.92 HOURS, CP= .50 VOL= 1.00

5.	48.	97.	59.	84.	111.	138.	162.	181.	196.
205.	208.	207.	190.	178.	167.	156.	147.	137.	129.
121.	113.	106.	100.	93.	88.	82.	77.	72.	68.
63.	59.	56.	52.	49.	46.	43.	40.	38.	35.

	33.	31.	29.	27.	26.	24.	23.	21.	20.	19.
	17.	16.	15.	14.	13.	13.	12.	11.	10.	10.
	9.	9.	8.	8.	7.	7.	6.	6.	5.	5.
	5.	4.	4.	4.	4.	3.	3.	3.	3.	3.
	3.	2.	2.	2.	2.	2.	2.	2.	2.	

0

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	END-OF-PERIOD FLOW COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	34.02	31.54	2.48	137131.
										1 864.11	801.11	63.11	3883.121

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTE

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ROUTING DATA

CLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1013.	-1

STAGE	1013.10	1013.00	1014.00	1015.00	1016.00	1017.80	1018.00	1018.50	1019.00
1019.50									
FLOW	0.00	20.00	65.00	200.00	310.00	630.00	680.00	1210.00	1920.00
2860.00									
SURFACE AREA=	0.	6.	14.	18.	30.	41.			
CAPACITY=	0.	30.	66.	116.	353.	707.			
ELEVATION=	997.	1013.	1017.	1020.	1030.	1040.			

CREL	SPWID	COQW	EXPW	ELEVL	COOL	CAREA	EXPL
1013.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	DAM DATA			
	TOPEL	COOD	EXPD	DAMWID
	1017.0	0.0	0.0	0.

PEAK OUTFLOW IS 1688. AT TIME 41.67 HOURS

PEAK OUTFLOW IS 3381. AT TIME 41.67 HOURS

********** ********** ********** ********** **********

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .50	RATIO 2 1.00
HYDROGRAPH AT	1	1.20	1	1696.	3391.
		3.11)		48.02))	96.04))
ROUTED TO	2	1.20	1	1688.	3381.
				47.79))	95.73))

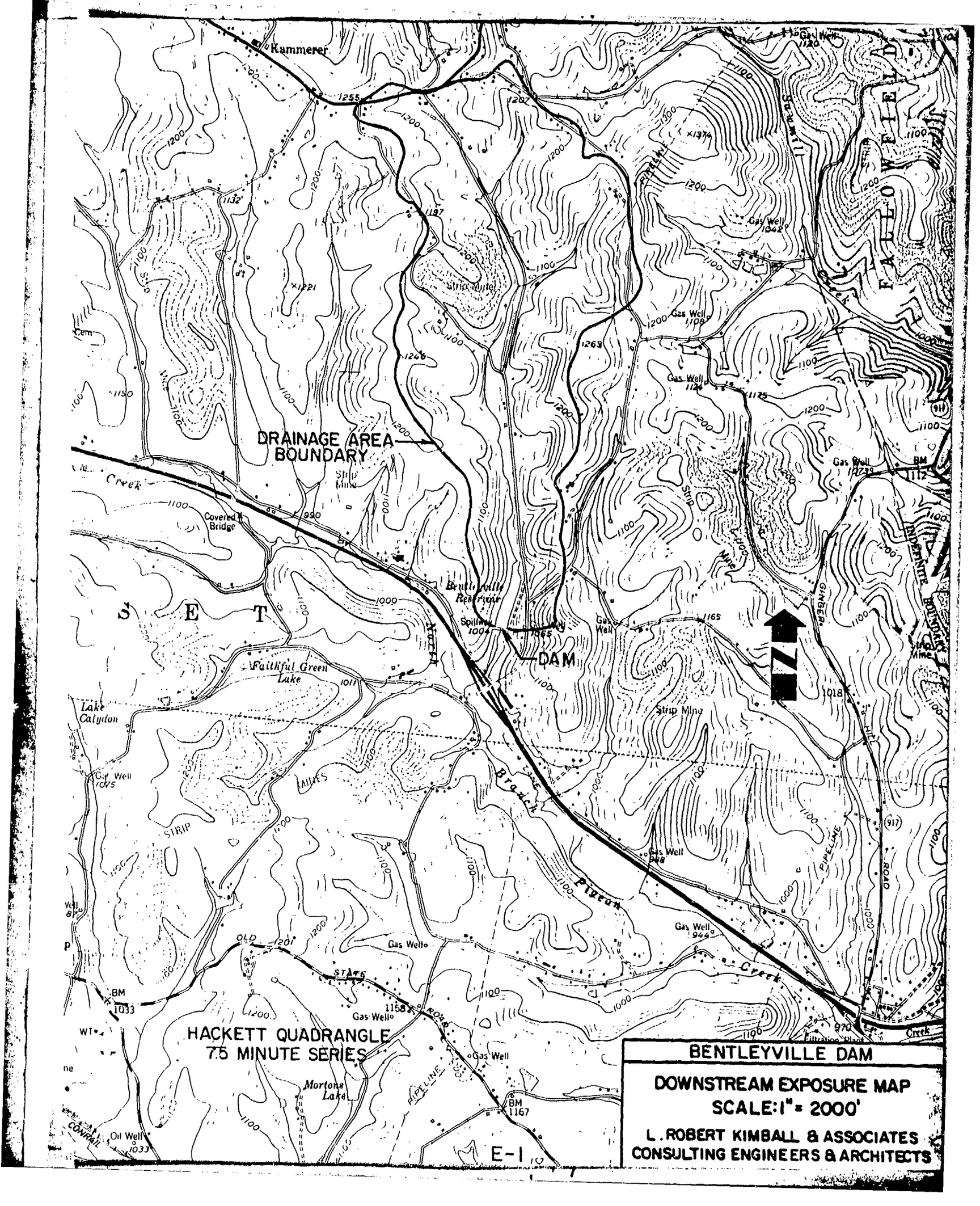
SUMMARY OF DAM SAFETY ANALYSIS

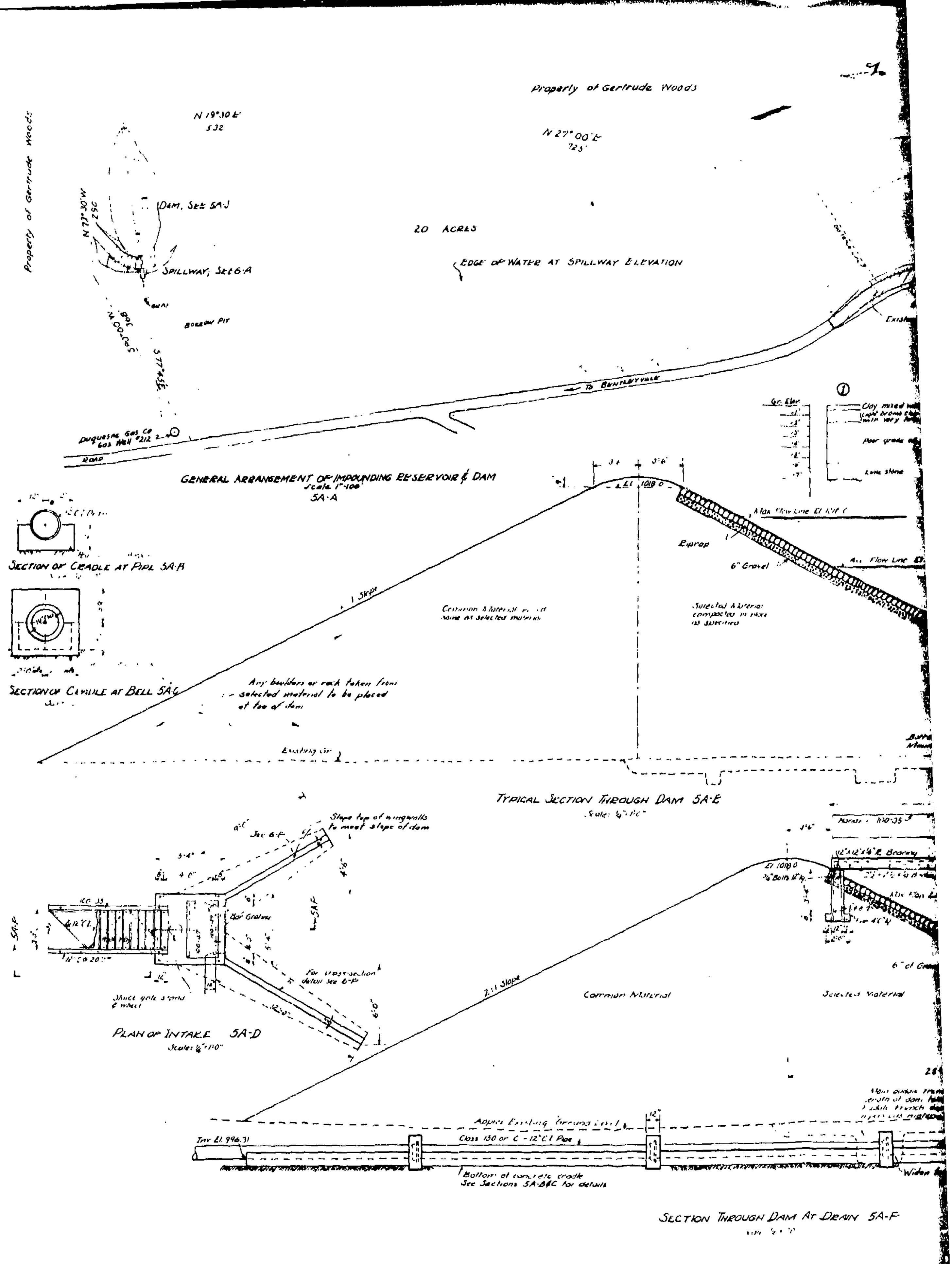
PLAN 1 .....

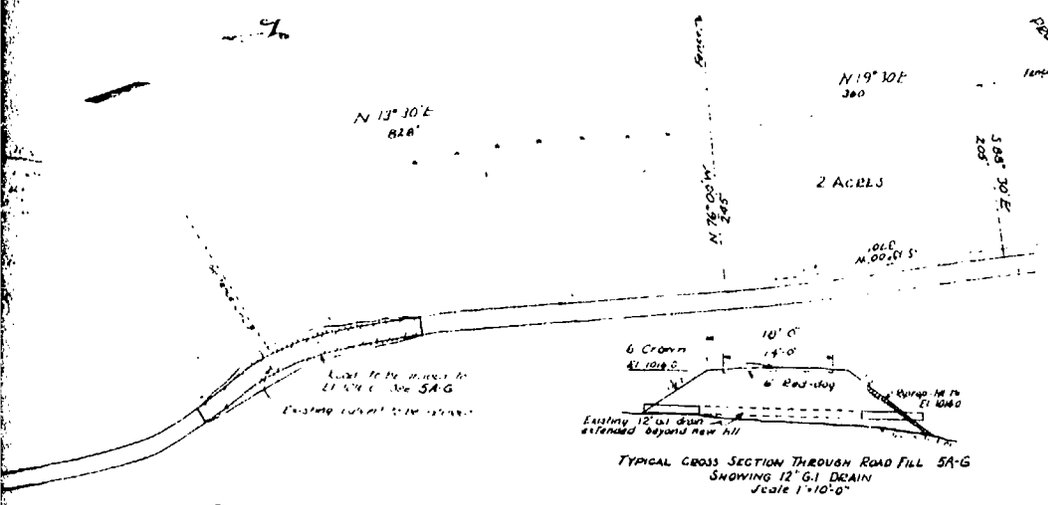
		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	1013.10	1013.10	1017.80
	STORAGE	301	301	795
	OUTFLOW	0.	0.	630.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	1014.84	1.04	963	1688.	8.33	41.67	0.00
1.00	1019.78	1.98	112.	3381.	10.17	41.67	0.00

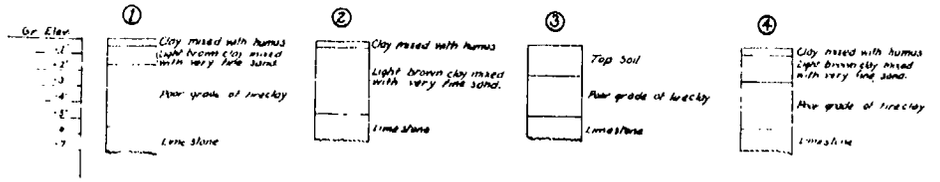
APPENDIX E
DRAWINGS


DRAINAGE AREA BOUNDARY
DAM
Bentleyville Reservoir
Faithful Green Lake
Lake Catalpa
Mortons Lake
Kammerer
Covered Bridge
Strip Mine
Gas Well
Pipeline
Creek
Branch
Road
HACKETT QUADRANGLE
7.5 MINUTE SERIES
E-1
BENTLEYVILLE DAM
DOWNSTREAM EXPOSURE MAP
SCALE: 1" = 2000'
L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS

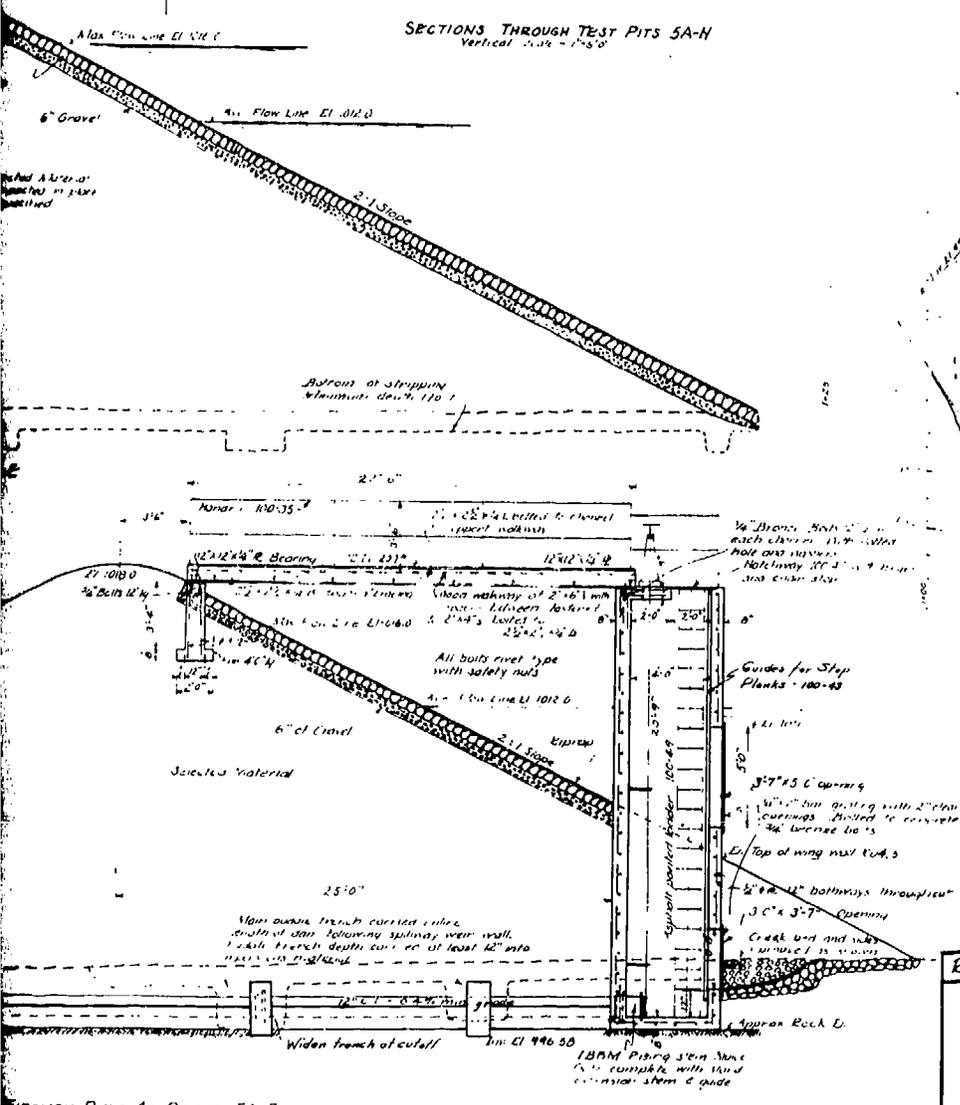

Property of Gertrude Woods
Property of Gertrude Woods
N 19°30' E
532
N 27° 00' E
725'
N 73°30' W
250
Dam, See 5A-J
20 ACRES
Edge of Water at Spillway Elevation
Spillway, See 6-A
Borrow Pit
S 00°00' W
S 77°45' E
To Bentleyville
Duquesne Gas Co
Gas Well #212
Road
GENERAL ARRANGEMENT OF IMPOUNDING RESERVOIR & DAM
Scale 1"=400'
5A-A
Section of Cradle at Pipe 5A-B
Section of Cradle at Bell 5A-C
El. 1018.0
Max Flow Line
Riprap
6" Gravel
1 Slope
Any boulders or rock taken from selected material to be placed at toe of dam
Existing Gr.
Clay mixed
Poor grade
Lime Stone
Gr. Elev.
TYPICAL SECTION THROUGH DAM 5A-E
Slope top of wingwalls to meet slope of dam
See 6-F
12" C.I.
Bar Grating
Sluice gate stand & wheel
For cross-section detail see 6-F
PLAN OF INTAKE 5A-D
Scale: 1/4"=1'0"
El 1018.0
12"x12"x4'-6" R. Bearing
2:1 Slope
Common Material
Selected Material
Approx Existing Ground Level
Inv El 996.31
Class 150 or C - 12" C.I. Pipe
Bottom of concrete cradle
See Sections 5A-B&C for details
SECTION THROUGH DAM AT DRAIN 5A-F



TYPICAL CROSS SECTION THROUGH ROAD FILL 5A-G
SHOWING 12" G.I DRAIN
Scale 1"=10'-0"

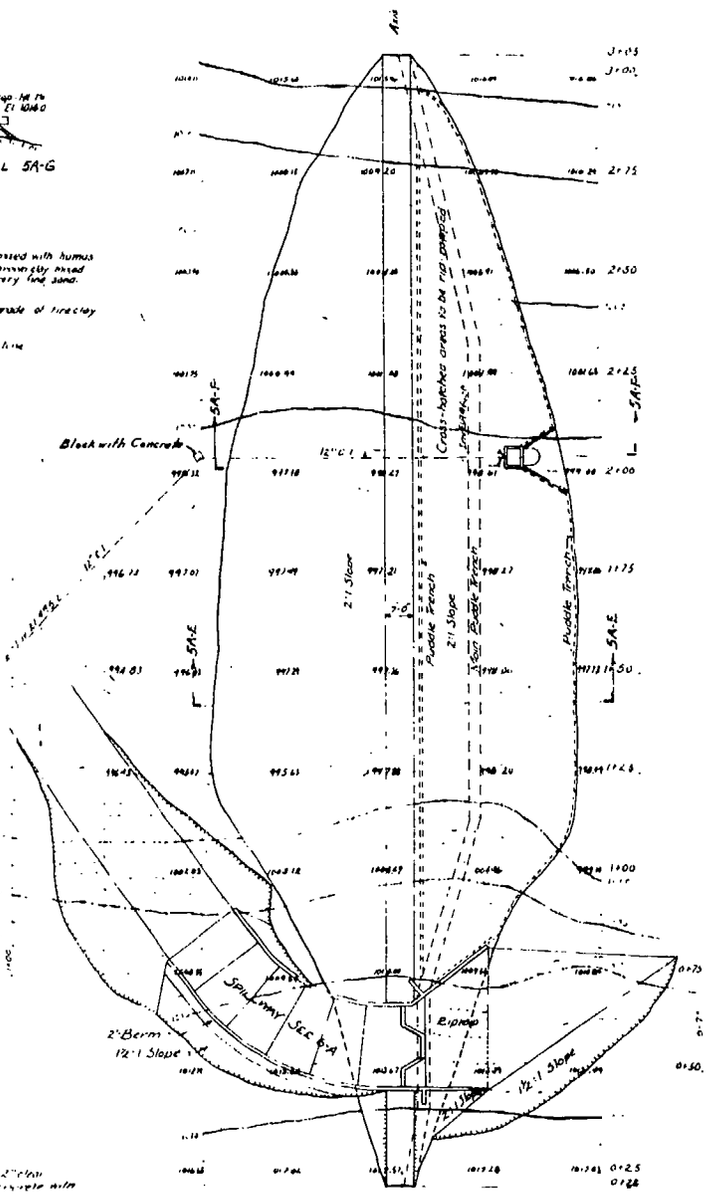


SECTIONS THROUGH TEST PITS 5A-N
Vertical Scale - 1"=5'0"



THROUGH DAM AT DRAIN 5A-F

Concrete to be 1-2-3½ mix
See Dwg. 2077-8 for General Notes



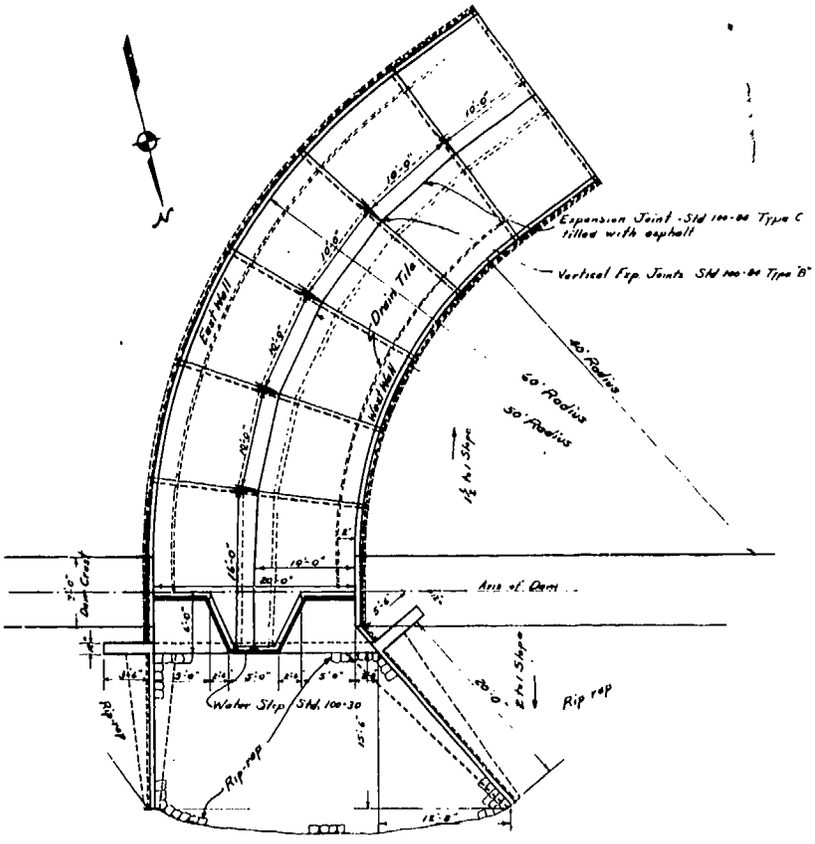
LAYOUT OF DAM 5A-J
Scale: 1"=20'-0"

REVISIONS	APPROVAL

BOROUGH of BENTLEYVILLE, PA.
IMPOUNDING RESERVOIR
GEN'L LOCATION & PLAN
Scale: As shown Jan. 13, 1930
DR
TR
CH
CK
The Chester Engrs.
Century Bldg - Pittsburgh
2077-5A

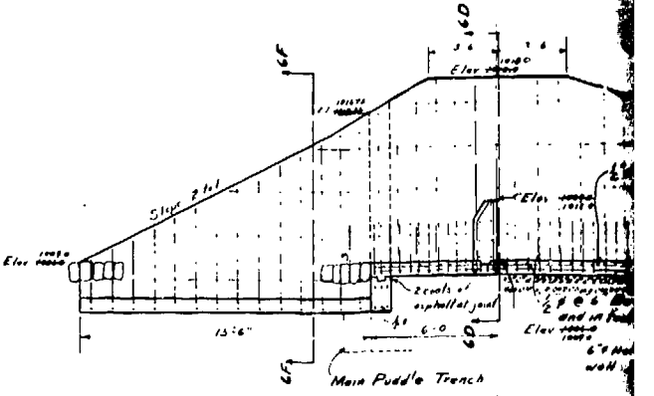
PWA PROJECT DOCKET Nº PA. 1149-D.S.

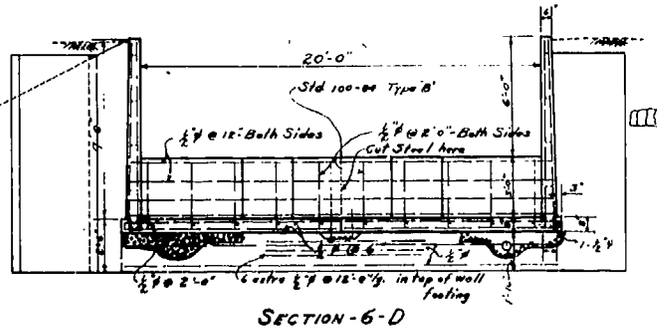
E 2



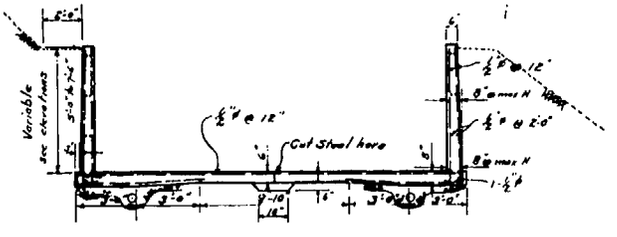
PLAN -6-A

Scale ⅛"=1'-0"

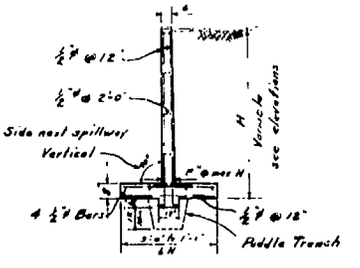




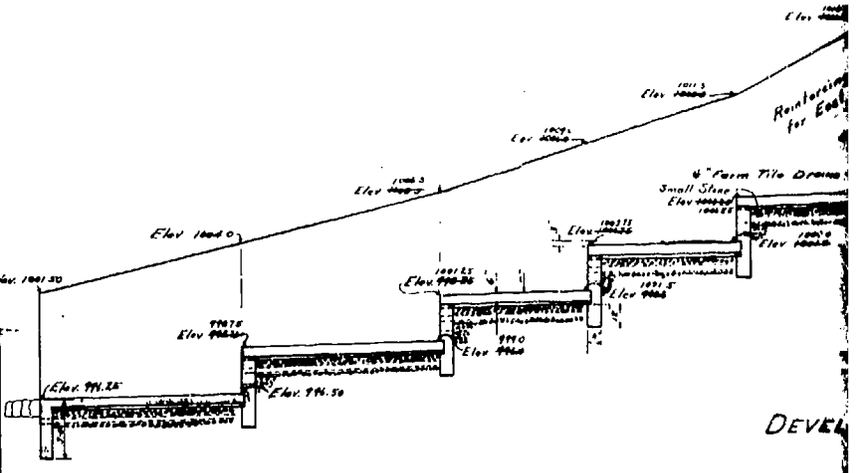
SECTION - 6-D



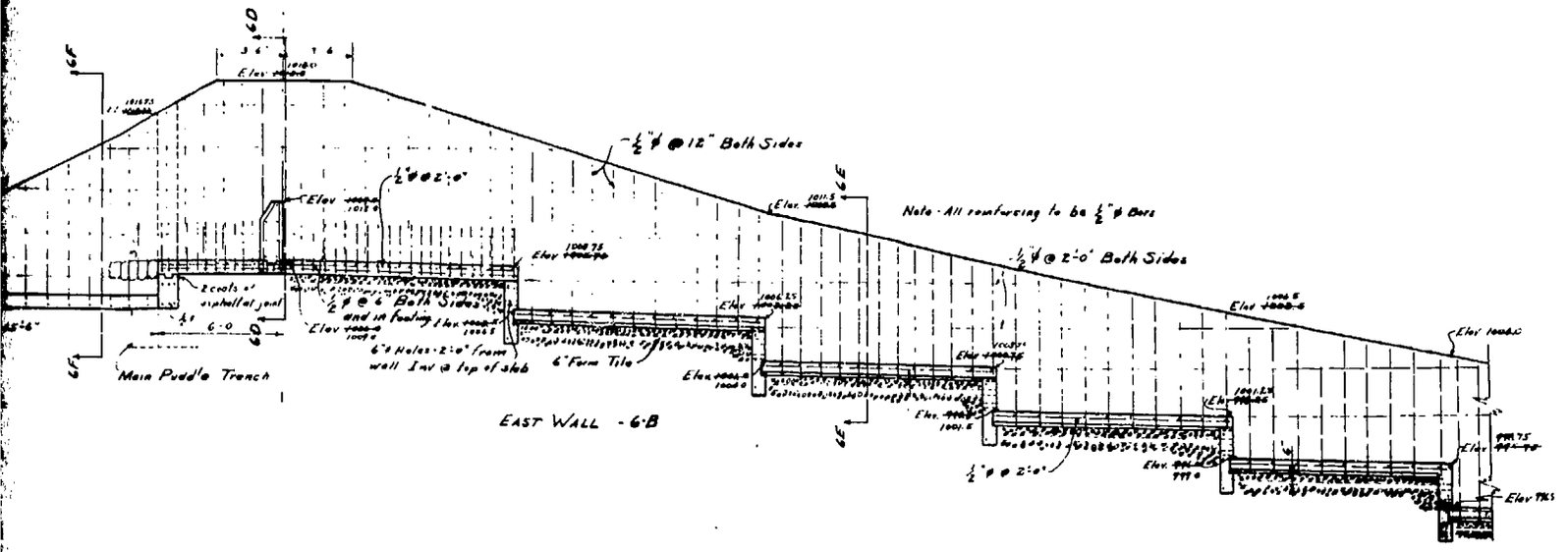
SECTION - 6-E Not to Scale



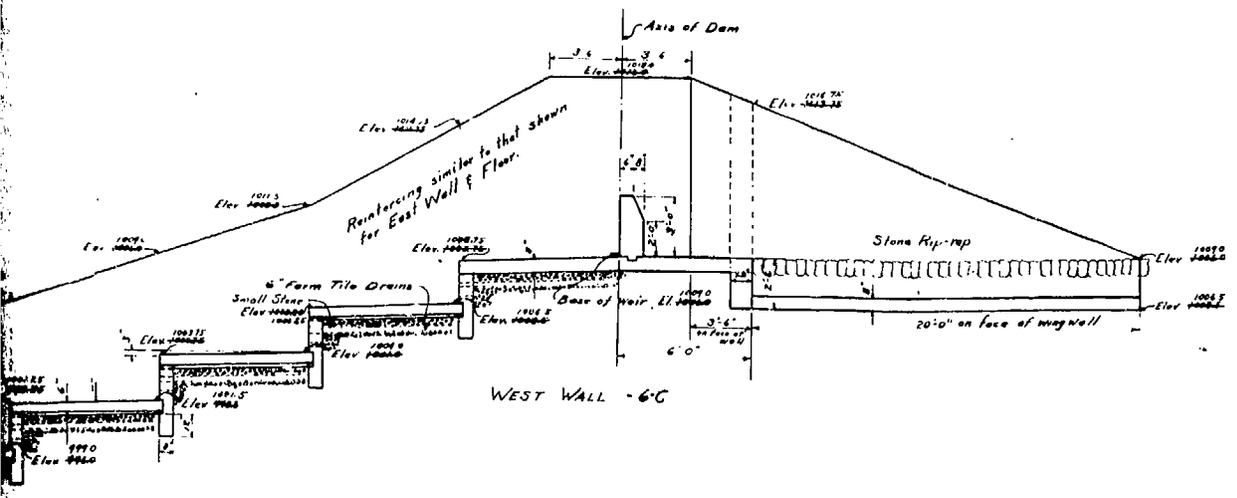
SECTION - 6-F



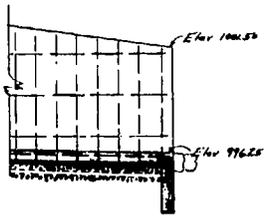
DEVEL



EAST WALL - 6·B



WEST WALL - 6·C



DEVELOPED ELEVATIONS OF SPILLWAY

Scale ¼"=1'-0"

Not To Scale - Use Dimensions

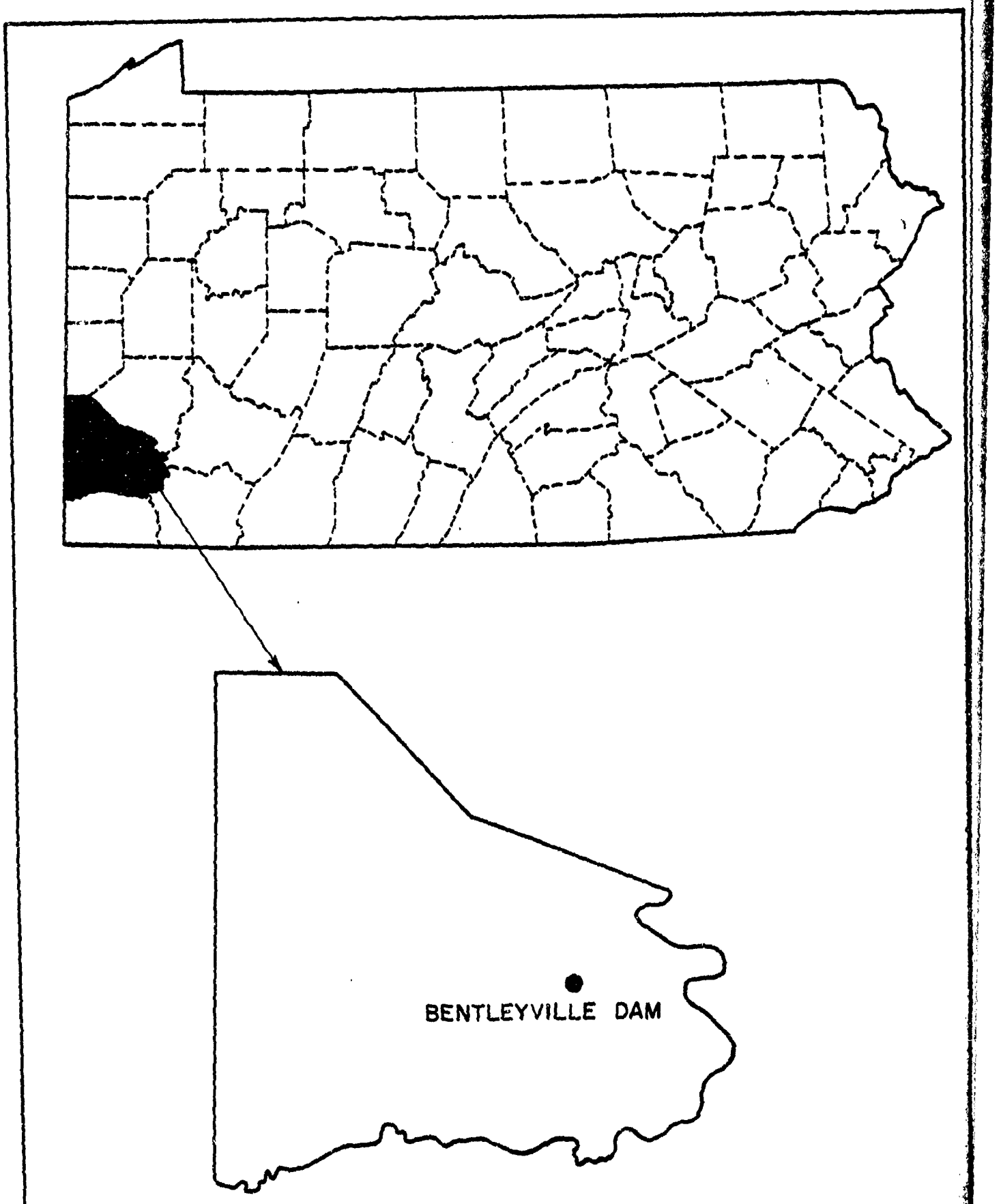
See Dwg 2077-a for General Notes

REVISIONS	APPROVAL	BOROUGH of BENTLEYVILLE, PA. IMPOUNDING RESERVOIR SPILLWAY & DETAILS
JAN. 13, 1938		Scale:- As shown Nov. 1937.
		DR. GEP TR. GAB CH. OK. The Chester Engrs. Century Bldg. Pittsburgh. 2077-6

P.W.A. PROJECT DOCKET No. PA. 1149 DS

E 3

1 2



SITE LOCATION MAP
WASHINGTON COUNTY, PENNSYLVANIA

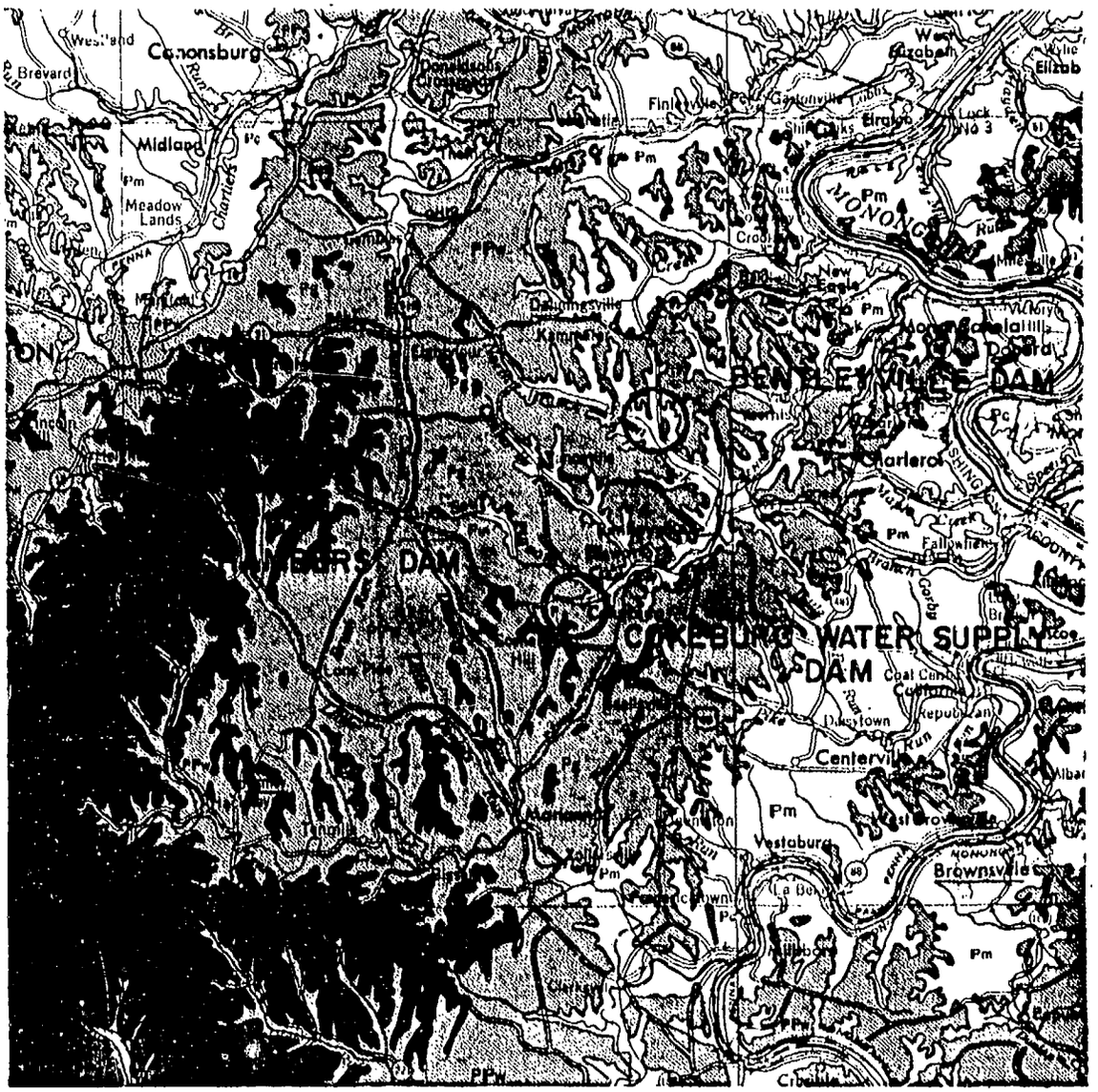
APPENDIX F
GEOLOGY

General Geology

The Bentleyville Dam is located in the Pittsburgh Plateaus Section of the Appalachian Plateau Province. This section typically consists of rounded hills and ridges formed by stream erosion of a former plainlike area. In the study area, the ridges are more definite and folds are slightly broader. The sediments are deformed by several sub-parallel secondary folds which are superimiposed upon a major spoon-shaped trough of first magnitude in southwestern Pennsylvania and adjacent regions. The axes of these folds trend about N30-50°E, plunging gently southward. The Bentleyville Dam lies on the common flank of the Amity Anticline and Pigeon Creek Syncline. The Amity Anticline strikes about N36E in the area of the dam. The strata beneath the dam strike this same general direction and dip gently to the southeast.

The rock underlying the dam belongs to the upper member of the Pittsburgh Formation of the Monongahela Group of Upper Pennsylvanian Age. It is composed of approximately four beds of argillaceous limestone alternating with units of greenish-gray mudstone, siltstone, and sandstone; some sandstone being massive. It is about 80 feet thick. The Benwood Limestone of the Sewickley Member, which lies beneath the upper member of the Pittsburgh Formation is known to have good water - bearing properties. The Monongahela Group extends to the base of the Pittsburgh coal seam.

The Bentleyville Dam is located in the Main Bituminous Coal Field. Principal coal beds which underly the dam are the Sewickely, Redstone, and Pittsburgh seams. They are about 125 feet, 200 feet, and 250 feet beneath the dam, respectively. As of 1974, the Pittsburgh coals extent of mining was just south of the Bentleyville Dam near the Route 70 intersection.



GEOLOGIC MAP OF THE AREA AROUND CHAMBERS DAM, COKEBURG WATER SUPPLY DAM AND BENTLEYVILLE DAM

SCALE: 1:250,000

PERMIAN

Greene Formation

Cyclic sequences of sandstone, shale, red beds, limestone and coal; base at the top of the Upper Washington Limestone.

PERMIAN AND PENNSYLVANIAN

PPm

Washington Formation

Cyclic sequences of sandstone, shale, limestone and coal; some red shale; some mineable coal. Base at the top of the Waynesburg Coal.

PENNSYLVANIAN

APPALACHIAN PLATEAU

Pm

Monongahela Formation

Cyclic sequences of sandstone, shale, limestone and coal; limestone prominent in northern outcrop areas; shale and sandstone increase southward; commercial coals present, base at the bottom of the Pittsburgh Coal.